Health, Disability Insurance and Retirement in Denmark

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1. Introduction

Labor force participation of older persons varies greatly both between countries and within countries over time. Individual health status, labor market conditions and social security program provisions all play a role in this. Disability Insurance (DI) programs are at the interface between social security provision, labor market conditions and health, and may play an important role for many persons as they move from employment to retirement from the labor market. In principle, it may be the case that changes in DI participation rates reflect changing health and changing labor market conditions. However, trends in DI participation appear to be unrelated to changes in mortality and health. Differences in health between countries would need to be much larger than those revealed in comparable survey data in order to account for differences in DI participation (Milligan and Wise, 2011). In many countries DI effectively provides early retirement benefits before eligibility for other social security programs begins. This begs the question: given health status, to what extent are the differences in labor force participation for seniors across countries determined by the provisions of DI programs? Answering this question is a challenge because measuring health is notoriously difficult and DI programs interact with social security provisions in different ways across countries.

Social security programs in general have been shown to provide strong incentives for older workers to exit from the labor market at certain ages (Gruber and Wise, 2004). In that volume, incentives were characterized by an option value model that allows the expected future consequences of current work decisions to be accounted for (Stock and Wise, 1990). This was implicitly an inclusive option value, in the sense that different pathways to retirement were included in a single summary measure of expected future consequences. Several countries with extensive DI programs, such as Sweden (Palme, 2004) and Denmark (Bingley, et. al., 2004) included a DI retirement pathway probabilistically as part of the inclusive option value. In the current volume, because DI programs are of primary interest, for the sake of greater comparability, DI pathways contribute to inclusive option values in a similar way across all countries.

In order to control for health one needs to follow individuals over time either with repeated survey questions about self-assessed health or administrative data about health care usage. Different countries have different health data sources. Even SHARE countries which follow a survey protocol to maximize comparability across countries might have different modes of response between populations, which makes comparison response-by-response difficult. Each of the studies in this volume calculates a single health index on the basis of the first principal component of their own sets of health measures. Most of the analyses are conducted on the basis of quintiles of these indices. Other countries use self-assessed health from surveys, whereas Sweden and Denmark use administrative records of health care usage, as the source of health measures for calculating principal components.

Further, to identify incentive effects we need to observe variation in pension program provision between individuals, and ideally within individuals over time by way of pension program changes or reform. We choose an observation period 1996-2008. That is from the first year that we can observe health care usage spanning the population based on administrative records, through the announcement of a major pension program reform in 1998 and beyond full enactment of the new law in 2006.

From our descriptive analyses we can see similar gradients in DI participation rates by health quintile and by level of completed schooling. Those in worse health and with less schooling are more likely to receive DI at some point from age 50. Health gradients across quintiles in DI participation are almost twice as steep as education gradients across levels. We find that pension program incentives in general are important determinants of retirement age. Individuals in poor health are significantly *more* responsive to economic incentives than those in better health, and those with low schooling are significantly *more* responsive to economic incentives than those with long schooling. Hence low schooling and poor health are associated with greater DI participation, and those with low schooling and poor health are also most responsive to economic incentives.

The remainder of the paper is organized as follows. Section 2 shows background trends in labor force and DI participation over time by schooling and health. Section 3 presents the empirical approach, describing pathways to retirement, how they are weighted, describing the health index and the option value calculations. Section 4 presents results from estimating option value models of retirement controlling for health in various ways. Section 5 shows goodness-of-fit measures and conducts counterfactual simulations to illustrate some implications of the results. Section 6 summarizes and concludes.

2. Background

Previous studies have shown how trends in labor force participation for seniors have only a weak relationship with changes in mortality and other measures of health over time and across countries (Milligan and Wise, 2012). Neither did there appear to be any relationship between the development of DI programs and changes in mortality and measures of health. These findings were on the basis of a broad view of disaggregated data covering a dozen countries and spanning several decades. In the current paper we want to analyze how individual retirement behavior is related to DI provisions, when controlling for individual variations in health and other characteristics. As background for this micro-analysis, in this section we describe trends over time in DI participation, labor force participation and employment by age, and correlate these with individual characteristics: gender, health status and educational attainment.

Time series of DI participation rates are shown in Figure 1 for different age groups 50-54, 55-59 and 60-64 separately for men in the left pane and women in the right pane. Women have higher mean participation rates than men and older groups have higher participation rates than younger. The youngest group has stable DI participation throughout the period for both genders, at 8 percent for men and 12 per cent for women. DI participation has declined markedly for those aged 60-64, falling from 21 to 13 per cent for men and a dramatic 36 to 17 per cent for women.

The DI participation rates of figure 1 are now set alongside employment rates in figure 2 which shows time series for different age groups 50-54 in the upper panes, 55-59 in the middle panes and 60-64 in the lower panes, separately for men in the left panes and women in the right panes. A high degree of symmetry is evident, especially in the older group in the lower panes, whereby falls in DI participation are about two thirds of the size of employment increases. Indeed, for women aged 60-64, from 1999 employment is more common than DI participation.

Associations with health status and schooling levels are shown in the next three figures. Figure 3 shows DI participation rates for age group 55-64 by schooling for selected years, separately for men in the left pane and women in the right pane. There is a clear gradient in schooling in that those with lower education have higher rates of DI participation. Graduating high school approximately halves the DI rate, falling from 24 to 13 per cent for men and from 35 to 17 per cent for women in 1996. Subsequent educational attainment is associated with an approximately 3 per cent reduction in DI rates for some college and another 3 per cent reduction for graduating college. There is no discernible change in the educational gradient over time.

In the following illustrations and for most of the econometric analysis, health status is characterized by quintiles of a health index. Calculation of the index is described in Section 3.c. Figure 4 shows DI participation rates for age group 55-64 by health quintile for selected years, separately for men in the left pane and women in the right pane. There is a clear gradient in health in that those with worse health have higher rates of DI participation. Our quintile grouping resolves into three different DI rates, the worst quintile followed by quintiles 2 and 3 at a similar but lower DI rate, followed by better health quintiles with almost no DI recipients. The fall in DI rate from best quintile to 2 and 3 is more marked than for schooling, falling from 48 to 25 per cent for men and from 61 to 37 per cent for women in 1996. There is no discernible change in the health gradient over time.

The joint distribution of DI participation rates by schooling and health quintile together is shown in Table 5 for age group 55-64, separately for men in the upper pane and women in the lower pane. Subpopulations with worst health and lowest schooling have highest DI participation rates, at 46 percent for men and 55 per cent for women. At the opposite corner of the table, men and women in the best health and a college degree both have a DI rate of less than one per cent. Within each health quintile there is still a marked schooling gradient in DI participation rates. Similarly, within each educational level there is still a marked health gradient. Health is the most important marginal distribution, with 17% of men and women receiving DI of those in worst health with a college degree, whereas only 2% of men and women in best health and less than high school participate in DI.

Information from Table 5 is further split by selected years in Figure 5 which presents DI participation rates for the age group 55-64 jointly by schooling and health, separately for men in the left pane and women in the right pane. Joint gradient in DI participation rates by health and schooling is maintained proportionally throughout, with worst health and lowest schooling men and women in 1996 at 57% falling to 37% by 2008. The fall of one third for this group over the 12 years is similar in magnitude to the DI participation rate difference for those in worse health between some high school and some college.

In the final two sets of background figures, employment rates are associated with schooling and health. Figure 6 shows employment rates for age group 60-64 by schooling over time, separately for men in the left pane and women in the right pane. Men have higher employment rates than women. Indeed, men with some college have similar employment rates to women with a college degree, and men with a high school degree have similar employment rates to women with some college. There are similar upward trends in employment rates for the three education groups without a college degree. The range of mean employment rates across levels of schooling is narrower for men, ranging from 48 to 80 per cent, than for women, ranging from 26 to 70 per cent, in 2008 for example.

Figure 7 shows employment rates for age group 60-64 by health quintile over time, separately for men in the left pane and women in the right pane. There is a clear health gradient in employment rates, with those in worst health having lowest employment rates, and those in the best two health quintiles having highest employment rates. Employment rates across all health quintiles for men and women increase uniformly over the sample period. The increase in employment rates 1995-2008 by about 20 per cent points is similar to the difference moving from the two worst health quintiles to the second best.

In summary, our years of observation 1995-2008 covers a period of falling DI participation, increasing labor force participation and increasing employment for seniors, especially those aged 60-64. There are steep gradients in health, with those in worst health more likely to participate in DI and less likely to be in employment. There are similar almost as steep gradients across the schooling distribution, with those without a high school diploma more likely to participate in DI and less likely to be in employment.

3. Empirical Approach

Our goal is to estimate the relationship between DI provisions and retirement age, given health status. In order to do this we need to consider all transfer programs relevant for the transition from work to retirement for seniors. These different pathways to retirement need to be combined in a weighted average measure which summarizes their relative potential importance. An inclusive option value framework will be introduced to characterize incentives implicit in the programs to retire at different ages. Finally we need to condition on health in a way which is comparable across datasets and countries. The following four subsections present these elements of our empirical approach.

a. Pathways to retirement

There are three main pension programs supporting income in retirement. First is a disability insurance program (*førtidspension*, hereafter DI) available for those aged 18-66 and later 18-64 who have permanent social and/or health impairments that reduce work capacity. Second is a contribution-based but largely tax financed Post Employment Wage program (*efterløn*, hereafter SS) which is essentially unemployment insurance benefit without a job search requirement available for ages 60-66 and after 2006 from 60-64. Third is Old Age Pension (*folkepension*, hereafter OAP) which is a demogrant available from age 67 and after 2006 from age 65, based on years of residence. Our period of analysis 1995-2008 is chosen to span reforms in DI stringency and SS/OAP incentives in order to provide variation by which to identify the effects of program provisions on the retirement age for older workers.

SS was introduced in 1979 for ages 60-66 and existed largely unchanged until reforms in 1992 and 1999. The 1992 rules are relevant for the first part of our sample period. Eligibility from 1992 to 1999 required membership in an unemployment insurance fund for at least 20 of the last 25 years. An individual was allowed to work for a maximum of 200 hours. If the 200 hours was exceeded, it resulted in a permanent disqualification from the program. For individuals claiming SS at ages 60-62, the benefits for the first two years were at the level of unemployment insurance and reduced to 80% for the last 4 years. Delaying SS until age 63 or older gave benefits at 100% of the max UIB level until age 66. This policy obviously incentivized retiring at age 63 rather than at younger or older ages. In 1995 unemployment insurance (UI) fund membership history requirements were increased from 20 to 25 out of the previous 30 years. Until 1999 only payouts from life annuities in occupational pensions were means tested.

An SS reform was announced in March 1999 and enacted by the 1 of July 1999. Means testing of payouts from all contributory pensions–whether they were paid out or not–was introduced for those claiming SS at age 60 and 61 . Those eligible for SS and not retiring now accumulate a quarterly €1.600 bonus beginning age 62. This reform shifted the retirement age incentive spike from age 63 down to age 62. The previous limitation of working at most 200 hours per year was removed and replaced by a high effective marginal tax rate. UI fund membership history requirements were further increased to 30 out of the last 35 years. Contributions were unbundled from UI and became separately elective.

An important element of the 1999 reform was the reduction in OAP age from 67 to 65. Those aged 60 and above at enactment (born before July 1939) were unaffected and could first claim OAP at age 67, whereas those born later could claim OAP from age 65. The change in OAP age was implemented from July 2004 through June 2006 and the maximum age for claiming SS benefits changed accordingly.

DI has existed in essentially the same economic form in the period 1984-2002 but with some stringency tightening in the 1990's. It was available to those with permanent social or physical work impairments depending on three levels of severity/generosity. During this period, real benefit levels were unchanged, but several stringency measures were introduced at different times. Three stringency reforms can be distinguished. First, during 1995-2002 a series of selective municipal award audits were undertaken, whereby each year two out of Denmark's fifteen counties were chosen and a random sample new benefit awards was drawn for re-assessment of eligibility. Second, in 1997 central government rebates to municipalities were reduced for DI expenditure on DI to individuals aged 60 and above, bringing refunds into line with those for younger age groups. Third, in 1998 municipalities were required to first consider whether other locally administered programs, such as work re-habilitation and disability wage subsidies, might be relevant before processing an application for DI.

In 2003, the government simplified DI for new awards, by reducing the number of levels from three to one but also introduced an array of condition-and needs-specific financial additions. These additions make net changes to incentives due to the reform difficult to characterize for systematic analysis.

Other relevant related programs for those in short-term poor health, with short-term or permanent work impairments but some remaining work capacity are sickness benefits (*sygedagpenge*), rehabilitation benefits (*revalidering*) and disability wage subsidies (*fleksjobs*) respectively. We do not consider these programs as pensions financing retirement because they involve some degree of attachment to the labor market. Nevertheless, they are worth mentioning because of their relevance at the interface between health, work and retirement. Work sickness absence benefits and rehabilitation are awarded temporarily. Disability wage subsidies are a payment at the level of the minimum wage for permanently reduced work capacity. Individuals in this program are employed, or unemployed and seeking work, and therefore not retired for modeling purposes.

b. Calculating the probabilities of different pathways

An option value incentive measure needs to combine provisions across different potential pathways to retirement. In order to integrate DI we need to impute to each person a probability that DI is a realistic option. These probabilities can then be used as weights to combine pathways into a single inclusive option value measure. We calculate a stock measure of calculating DI probabilities from the proportion participating in DI by different cells combining individual characteristics. Cells are calculated for those aged 55-64 by level of schooling, gender and year. Selected years of these DI weights are presented in Figure 3.

c. Health Index and Health Quintiles

A continuous health index needs to be created and divided into quintiles so as to be comparable with other countries. Poterba, Venti and Wise (2011) propose such an index be calculated from the first principal component of 27 health indicators from the HRS. In the Danish administrative registers we use the first principal component from hospital discharge records and prescription medicine purchases. The principal components analysis is conducted on the population aged 50-80 during the years 1994-2007.

From hospital records we consider all encounters, for both day patients and overnight stays. Each encounter has a primary diagnosis code (ICD-10) and duration. We aggregate diagnoses to the three-digit level, giving 160 distinct diagnoses after 12 diagnoses with fewer than 100 cases are dropped. Durations of hospital stays are summed over a two year period within each diagnosis for each person. In other words, hospitalization is characterized for each person as length of hospital stay over the previous two years with each of 160 primary diagnoses.

From prescription medicine records we consider all purchases from high street pharmacies. Each purchase has a drug code (ATC-5) and dosage. We aggregate drug codes to the three-digit level, giving 170 distinct drug types after 8 drug types with fewer than 100 persons purchasing are dropped. Dosages are normalized according to WHO defined daily dosages and summed over a two year period within each drug type for each person. In other words, drug consumption is characterized for each person as number of standard daily doses over the previous two years for each of 170 drug types.

Principal components are calculated over hospitalizations and prescriptions together in two year periods. For example, when modeling retirement behavior in 1996, principal components would be calculated for 1994-5; for behavior in 1997, principal components would be based on 1995-6, etc. The first principal component forms our health index. Figure 8 shows mean centile of the health index over age by gender in the left pane and by schooling level in the right pane. By convention a higher centile is taken to indicate better health. Men have a higher mean health centile than women. Note that it is conventional to observe that men have better self-reported health, less health care usage, but higher mortality than women of a similar age. Health declines with age and the gender health gap narrows from 5 centiles at age 50 to 1 centile at age 70. The gender health gap at age 60 corresponds to the mean health decline over 4 to 5 years. According to our health index, based on health care usage, a woman age 60 is as healthy as a man age 64. This is in spite of her having higher expected longevity.The right pane of figure 8 shows a health centile gradient in schooling with those with lowest schooling having worst health. The schooling health gradient narrows from 10 centiles at age 50 to 6 centiles by age 70, however the 3 health centile difference moving from high school graduation to some college persists.

d. Option Value Calculation

The goal of our analysis is to estimate the relationship between pension program provisions and age of retirement. Incentives implicit in pension program provisions can be characterized by the potential gain from postponing retirement until future ages. In order to do this we follow the option value approach of Stock and Wise (1990) and extend this to explicitly allow for different potential pathways to retirement in the form of an inclusive option value measure.

From the vantage point of each age *a* while in work, there are several possible pathways *(pa=1,..., PA)* to retirement, each with an associated utility stream *V* dependent upon age of retirement time *r*. A pathway constitutes a number of years of continued work, denoted in the first summation of equation (1), followed by the number of years receiving pension benefits specific to that pathway until death at age *A*, denoted by the second summation of equation (1). Expected utility at each future age *s* from the vantage point of each age E_a is weighted by the probability of survival to that age $p_{s|a}$ and discounted β^{s-t} back to the present. While working, wage income *ω(s)* is received at each age, while retired benefit income $B_{rk}(s)$ is received at each age dependent upon pathway and age of retirement*.* The utility function includes a parameter for leisure *κ,* which scales retirement benefits relative to earnings. Both incomes in work and retirement are raised to the power γ representing risk aversion:

$$(1) \qquad E_a\,\{V_{ka}(r)\} \;=\; \sum_{s=a}^{r-1} p_{s|a}\,\beta^{s-a}\big(\omega(s)\big)^{\gamma} + \sum_{s=r}^{A} p_{s|a}\,\beta^{s-a}\big(\kappa B_{rk}(s)\big)^{\gamma}$$

For each retirement pathway *pa*, the future age of retirement at which the expected discounted utility stream is maximized is denoted r^*. The comparison is between expected utility streams associated with all retirement ages until maximum age of retirement *R*. The option value of staying in work at the present age *a* compared to following eventual retirement pathway *pa* is defined as the difference between the maximum of expected utilities from future retirement ages along that pathway compared to retiring now:

(2) $$OV_{ka} \equiv \max_{a<r^*\leq R}[E_a\{V_{ka}(r^*)\}] - E_a\{V_{ka}(a)\}$$

Having defined the OV of staying in work from the vantage point of each age *a* for each retirement pathway *pa,* it remains to weight each pathway with the probability P_k so that it represents a set of relevant alternatives for each individual. An inclusive OV measure combines routes weighted by the probabilities that they are relevant as follows:

(3) $$OV_a = \sum_{k=1}^{K} P_k OV_{ka}$$

This inclusive option value measure makes explicit the extension to the Stock and Wise (1990) option value approach that allows us to incorporate several different routes to retirement. This can be cast in a regression framework further allowing for differences in health status. Consider retirement status *R* for person *i* of age *a* in health quantile *j.* This is assumed to be a function θ_j of exogenous individual characteristics X_{ia} and a function δ_j of inclusive option value OV_{ia}. H_j is a measure of health and ε_{iaj} is an error term:

(4) $$R_{iaj} = \sum_{j=1}^{J}\left[\theta_j X_{ia} + \delta_j OV_{ia} H_j\right] + \varepsilon_{iaj}$$

Equation 4 is estimated as a probit model for year-to-year retirement. Retirement behavior is characterized an optimal stopping problem in that an individual remains out of the labor force once retired. Benefit collection and retirement are assumed to be synonymous. Pathways from the labor force to OAP could be direct or via DI, SS, or a private pension drawdown. Individuals are selected ages 57-66 and must be working in first year of observation. We assume a maximum age of retirement *R* at 67 and force those who are still working at age 66 to retire at 67 on OAP. We use population life tables for survival probability *s* from age *a* published in 2009 by age and gender for ages 58-99 and impose zero survival probability at age 100. After retirement, an individual leaves the dataset. Exits from the dataset due to death, migration or change of marital status are treated as missing at random. Observations for individuals who leave the dataset are used in estimation until the year before exit and the last observation is classified as working. Potential earnings profiles are assumed to be flat from age 57 with 1% real growth. Option value calculations assume knowledge of the pension and tax system as in place at the vantage point of observation. Individuals form expectations on the basis of that system and any future changes which had already been announced at that time. For the sake of comparison with other countries, preference parameters are fixed at the levels found in US data as discount rate $\beta=0.97$, utility of leisure $\kappa=1.5$ and risk aversion $\gamma=0.95$.

It is informative to present examples of these option values in order to fix ideas. Figure 9 shows mean option value for the 1941 cohort by age for each retirement path as well as for inclusive option value combining all pathways, separately for men in the left pane and women in the right pane. Option value falls with age. The fall is from a higher base for men compared to women, but the proportional fall over age is similar. DI option value declines smoothly, whereas SS option value slows its decline just for age 61 and resumes a decline thereafter more slowly. This reflects an absence of age related conditions for DI, but a post-reform penalty for SS at age 61 due to means testing of private pension wealth, followed by bonus payments for delaying SS retirement for each quarter beyond age 62.

4. Results

In this section we present estimates of the models constructed in the previous section. Option value is the main explanatory variable of interest and it is informative first to see how this evolves over age alongside retirement age to understand how it is driving the retirement decision modeling. Figure 10 shows per cent of men or women having reached maximum utility, or minimum option value, by age, separately for the pre-reform 1938 cohort in the left pane and for the post-reform 1941 cohort in the right pane. Also shown is the per cent retired by age for men and women. Per cent having reached minimum option value is higher for men than women and rises faster over age for women. The pattern is similar pre- and post-reform, but with a bigger share reaching minimum option value by each age pre-reform.

The remainder of the section presents estimates of option value coefficients and controls for different specifications and samples. Table 2A shows estimates from retirement probit regressions with option value as the key explanatory variable and health measures as controls. Each column is for a separate regression to check sensitivity of results to the inclusion of linear age versus age dummies, inclusion of additional covariates, and to different ways of controlling for health, by the health index of health quintiles. Option value has a negative and statistically significant effect on retirement. Estimates are similar regardless of how health is controlled for. OV coefficients are somewhat smaller with inclusion of additional covariates and considerably smaller with age dummies rather than linear age controls. Other covariates are significant with expected signs. Compared to the reference group in worst health, the healthier are less likely to retire. However, among the four healthy quintiles there is no gradient in retirement. There is a clear gradient in schooling whereby those with more schooling are less likely to retire.

An alternative parameterization of option values is as per cent gain in option value from delaying retirement. Table 2B shows estimates from retirement probit regressions with this as the key explanatory variable and health quintiles as controls. These show the effect of the utility gain from waiting to retire until the optimal age, scaled by the utility available by retiring immediately. Coefficients of interest are negative and statistically significant. Robustness across specifications is similar to that from Table 2A, with somewhat smaller coefficients when including covariates and considerably smaller coefficients when controlling for age with dummies rather than a linear term.

The most flexible specifications run models separately by different cuts of the data. Table 3A shows estimates from retirement probit regressions with option value as the key explanatory variable, run separately by health quintile. Each cell of the table corresponds to a separate regression, with specifications differing by column and health quintile sample differing by row. Estimates differ across specifications according to a similar pattern seen in Tables 2A and 2B. Those in worst health have the most negative option value coefficients, followed by those in the second worst health quintile, and the remainder in better health quintiles 3-5 have smaller coefficients but exhibit not obvious pattern between each other. So those in *worse health* are *more responsive* to pension incentives.

Using a more flexible specification than those presented in Table 2B, Table 3B shows estimates from retirement probit regressions with per cent gain in option value from delaying retirement as the key explanatory variables, split by health quintiles. Each cell is the coefficient of interest from a separate regression. There is a familiar pattern of sensitivity across specifications, but no systematic differences in coefficients across health quintiles.

Table 3C shows estimates from retirement probit regressions with option value interacted with the health index as the key explanatory variables. This is the continuous health index version of Table 3A, but further imposes that other covariates do not vary according to health whereas they were allowed to vary in Table 3A (not presented). Estimates of the interaction of option value with health index are negative, implying individuals in better health are more responsive to incentives. This is the opposite finding from Table 3A and is likely due to the restriction that other controls are not allowed to also vary by health.

Analogously to splitting the sample by health quintile, the next two tables split the population by level of education attainment. Table 4A shows estimates from retirement probit regressions with option value as the key explanatory variable, for samples split by schooling. Each cell of the table corresponds to a separate regression, with specifications differing by column and schooling level sample differing by row. Once again, estimates differ across specifications according to a similar pattern seen in Tables 2A and 2B. There is a clear gradient in coefficients across schooling samples, with those having least schooling having most negative option value coefficients, and gradually coefficients become less and less negative for samples with more and more schooling. OV coefficients for those without a high school degree are about five times as large as OV coefficients for those with a college degree. The biggest difference in coefficients is at the high school graduation margin.

Finally, Table 4B shows estimates from retirement probit regressions with per cent gain in option value from delaying retirement as the key explanatory variables, for different samples split by level of schooling. This shows a similar gradient to that presented in Table 4A.

a. Model fit

Estimates from Table 2A specification 4 are based on the full sample with option values, health quintiles, age dummies and a full set of controls. The top panes of Figure 11 show goodness-of-fit from this model in terms of observed and predicted hazard rates, separately for men in the left panes and women in the right panes. Hazard rate spikes at ages 60 and 62 are fitted well for both men and women. Estimates from Table 3A specification 4 are based on samples split by health quintile, with option values, age dummies and a full set of controls. Predictions by health quintile are presented in the middle panes of Figure 11 and track the average hazard rate quite closely, with worst health always clearly more likely to retire at all ages and a more modest gradient in predicted retirement hazard across the better health quintiles. Estimates from Table 4A specification 4 are based on samples split by schooling level, with option values, age dummies and a full set of controls. Predictions by schooling are presented in the lower panes of Figure 11 and track the average hazard rate closely for those with less than some college, but predicted hazards are more damped for those with some college and especially for college graduates.

b. Implications of the results

Counterfactual simulations help us understand how the provisions of DI and SS programs differentially affect retirement ages. Figure 12 shows survival rates in work by age for simulating that only the DI retirement pathway is available or only the SS retirement pathway is available, separately for everyone in the left pane and for only those ever receiving DI in the right pane. Survival in work declines faster for simulations based on individuals who have ever received DI. For both the full population and those ever on DI, there is less survival in work simulating only the DI pathway.

A useful summary measure of the retirement consequences of our counterfactual simulations is the number of expected years of work after age 57. Figure 13 shows this together with two additional intermediate simulations which are also conducted and presented, for those ever receiving DI. The two new simulations involve first a random one third assignment to DI pathway and two thirds assignment to the SS pathway, and second a two thirds random assignment to DI pathway and one third to the SS pathway. For the full population SS pathway has 4.8 expected remaining years and the DI pathway has 4.5. For the sample of those who have ever received DI, the number of expected work years beyond 57 for the SS pathway is 3.8 compared with 3.6 for the DI pathway. Simulated changes in DI stringency are shown in the other two sets of bars in Figure 13. By randomly assigning first one third and then two thirds from the DI pathway to the SS pathway we tighten access to the DI program, and remaining work years increases from 3.60 first to 3.67 and then 3.73. This is a rather modest employment effect from making DI harder to access for a sample who have received DI.

5. Conclusion

From our descriptive analyses we can see similar gradients in DI participation rates by health quintile and by level of completed schooling. Those in worse health and with less schooling are more likely to receive DI at some point from age 50. Health gradients across quintiles in DI participation are almost twice as steep as education gradients across levels. We find that pension program incentives in general are important determinants of retirement age. Individuals in poor health are significantly more responsive to economic incentives than those in better health, and those with low schooling are significantly more responsive to economic incentives than those with long schooling. Hence low schooling and poor health are associated with greater DI participation, and those with low schooling and poor health are also most responsive to economic incentives.

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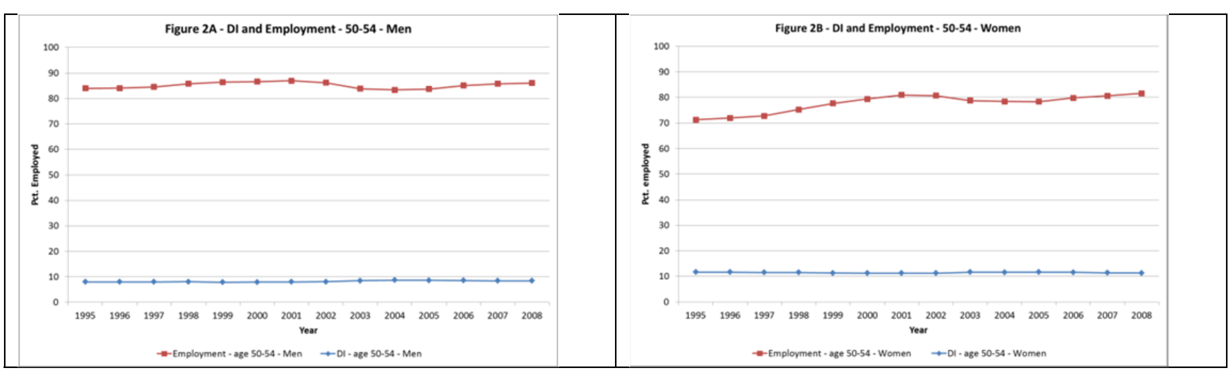
Figures and Tables

Figure 1

Figure 2



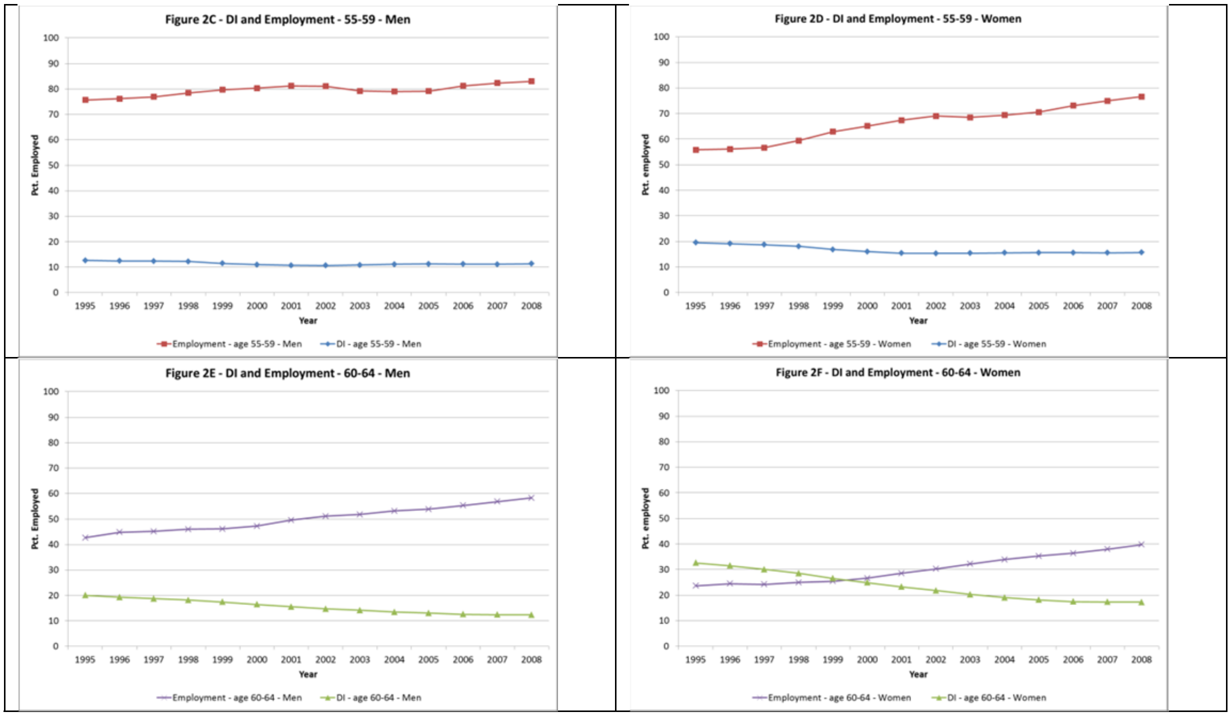


Figure 3

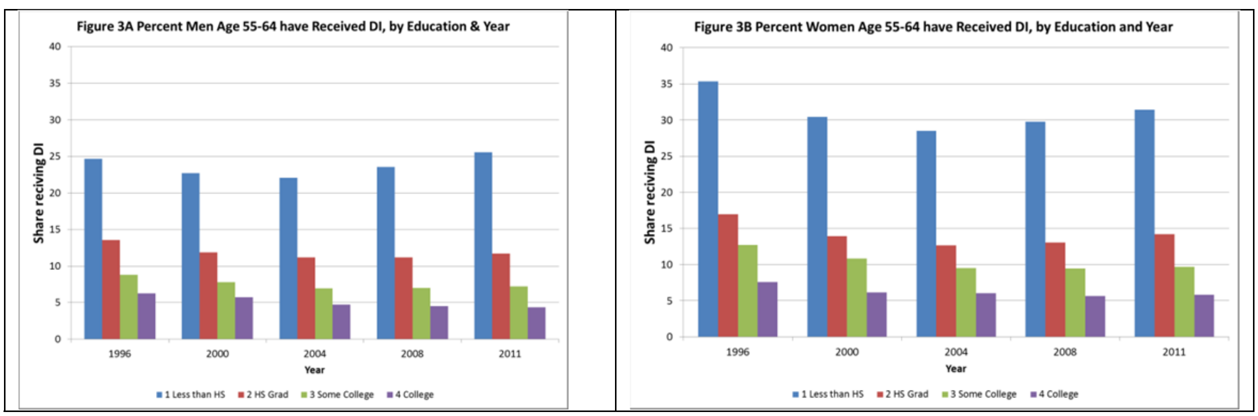


Figure 4

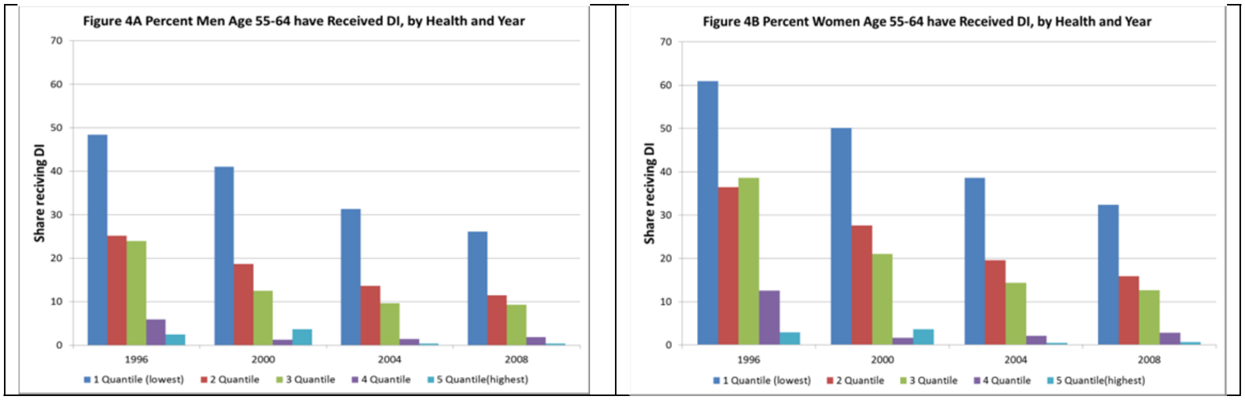


Figure 5

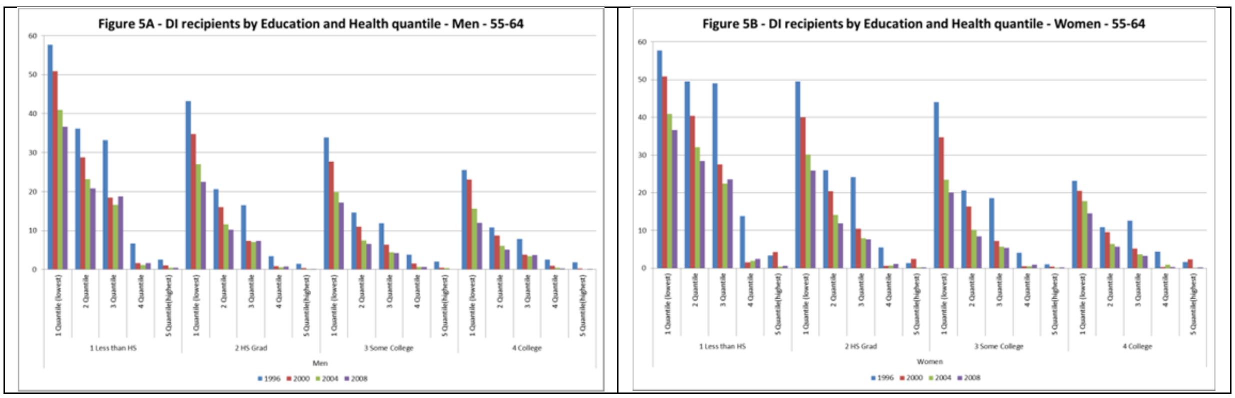


Figure 6

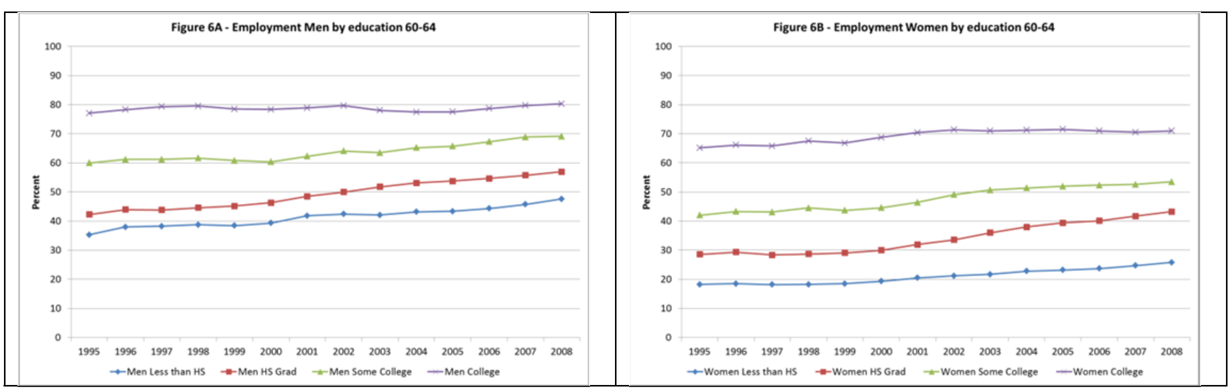


Figure 7

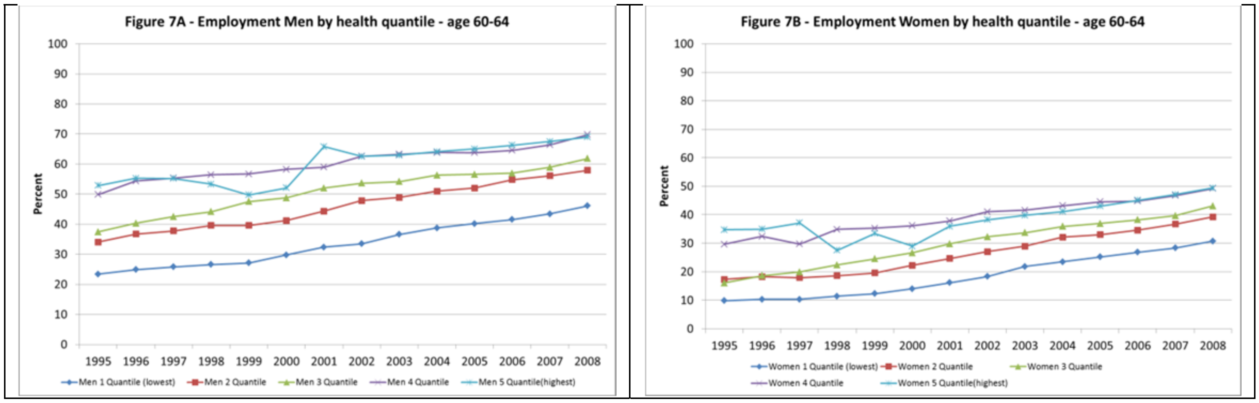


Figure 8

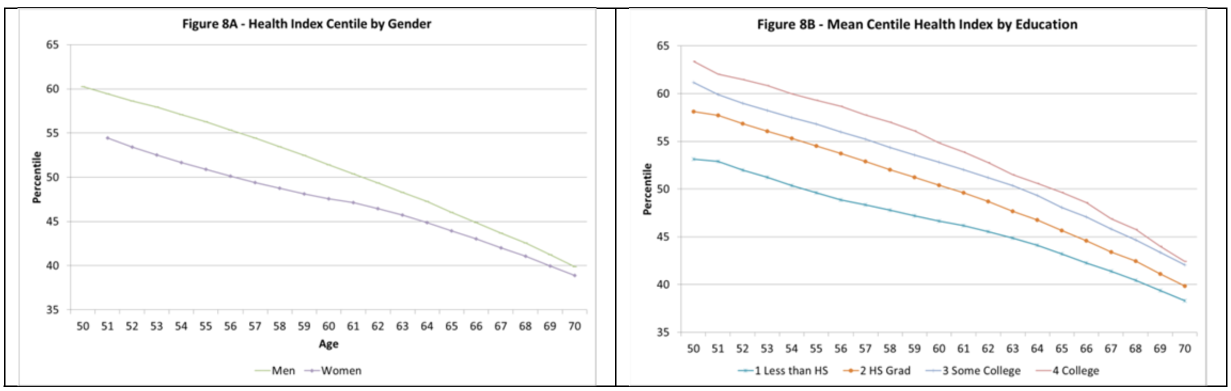


Figure 9

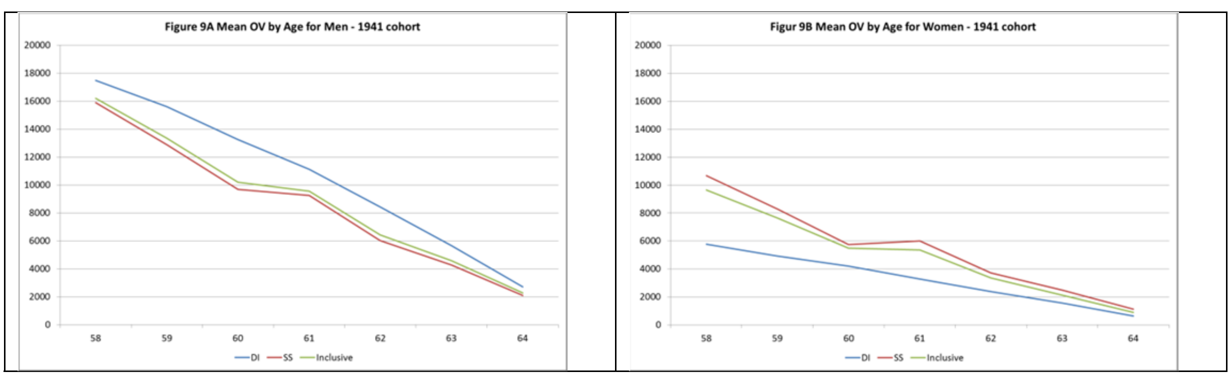


Figure 10

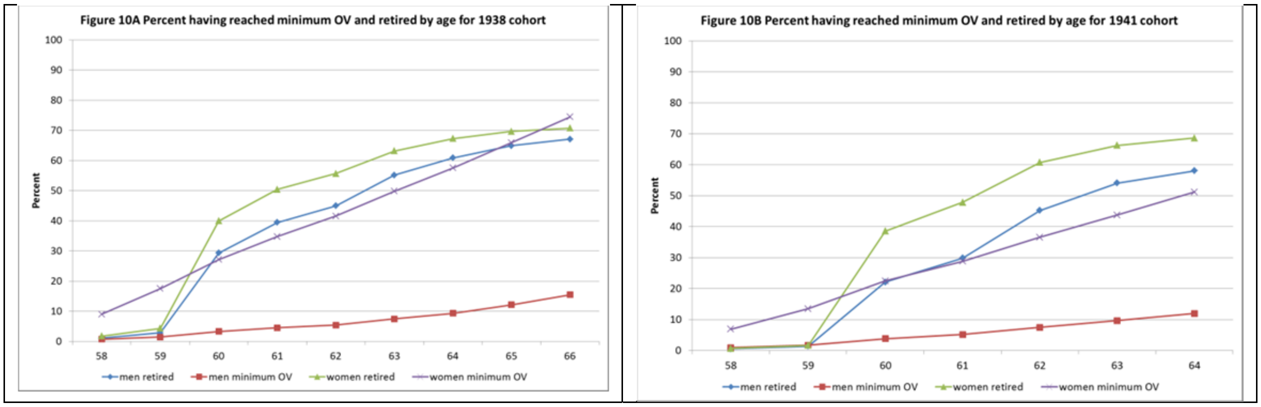
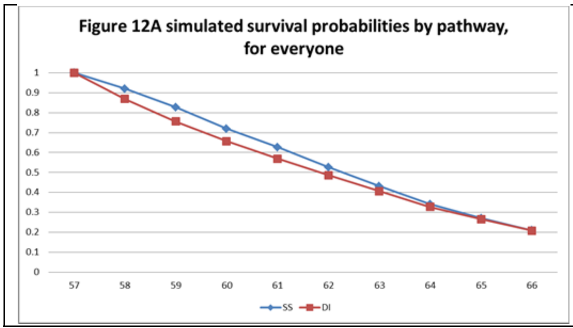


Figure 11

Figure 12



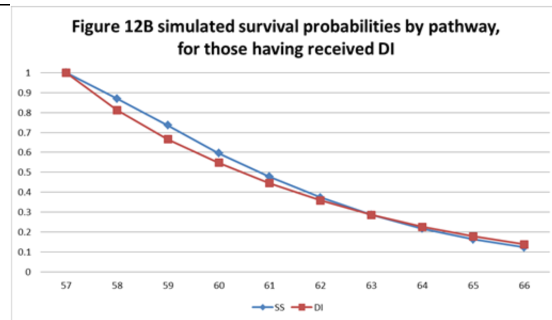


Figure 13

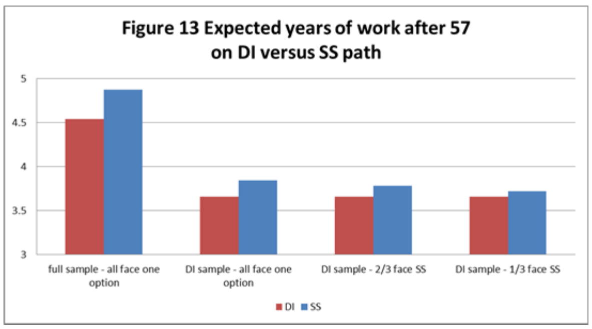


Table 1

Table 1 percent DI receipt age 55-64 by heath quintile and education						
	Men - health quintile					
	1 (low)	**2**	**3**	**4**	**5**	All
1 Less than HS	45.58	25.63	22.84	4.03	2.14	20.63
2 HS Grad	30.16	12.97	9.25	1.81	0.94	10.70
3 Some College	22.75	8.56	6.08	1.81	1.10	7.01
4 College	17.22	6.98	4.11	1.23	0.73	4.71
All	34.11	16.06	12.72	2.41	1.30	12.83
	Women - health quintile					
	1 (low)	**2**	**3**	**4**	**5**	All
1 Less than HS	55.11	35.59	33.46	7.32	2.50	28.91
2 HS Grad	32.92	15.63	11.96	2.44	0.86	12.66
3 Some College	25.78	11.43	8.30	1.83	0.69	9.51
4 College	16.98	7.28	5.05	1.33	0.49	5.66
All	42.12	23.55	20.72	4.25	1.48	19.02

Table 2A

Table 2a: Effect of Inclusive OV on Retirement

	Specification							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OV_Inclusive	-0.0907***	-0.0591***	-0.0775***	-0.0433***	-0.0903***	-0.0589***	-0.0773***	-0.0434***
	(0.0006)	(0.0005)	(0.0007)	(0.0005)	(0.0006)	(0.0005)	(0.0007)	(0.0005)
	[0,0647]	[0,0452]	[0,0504]	[0,0265]	[0,0642]	[0,0446]	[0,0501]	[0,0263]
Health Quint 2	-0.0033***	-0.0190***	-0.0007	-0.0162***				
(Second Lowest)	(0.0008)	(0.0006)	(0.0008)	(0.0006)				
Health Quint 3	-0.0101***	-0.0256***	-0.0089***	-0.0249***				
	(0.0008)	(0.0006)	(0.0008)	(0.0006)				
Health Quint 4	-0.0098***	-0.0228***	-0.0116***	-0.0250***				
	(0.0008)	(0.0007)	(0.0008)	(0.0007)				
Health Quint 5	-0.0020*	-0.0150***	-0.0047***	-0.0180***				
(Highest)	(0.0008)	(0.0007)	(0.0008)	(0.0007)				
Health Index					-0.0060***	-0.0063***	-0.0061***	-0.0064***
					(0.0005)	(0.0005)	(0.0005)	(0.0005)
Age	X		X		X		X	
Age Dummies		X		X		X		X
Female			0.0016*	0.0051***			-0.0001	0.0024***
			(0.0006)	(0.0005)			(0.0006)	(0.0005)
Married			-0.0198***	-0.0184***			-0.0198***	-0.0188***
			(0.0010)	(0.0008)			(0.0010)	(0.0008)
Spouse retired			0.0542***	0.0428***			0.0543***	0.0432***
			(0.0006)	(0.0005)			(0.0006)	(0.0005)
Total Assets			-0.0000***	-0.0000***			-0.0000***	-0.0000***
			(0.0000)	(0.0000)			(0.0000)	(0.0000)
Occup Dummies			X	X			x	x
Educ: <High School			-0.0024***	-0.0045***			-0.0025***	-0.0046***
			(0.0006)	(0.0005)			(0.0006)	(0.0005)
Educ: High School			-0.0194***	-0.0154***			-0.0195***	-0.0156***
			(0.0008)	(0.0006)			(0.0008)	(0.0006)
Educ: Some College			-0.0509***	-0.0362***			-0.0510***	-0.0367***
			(0.0011)	(0.0008)			(0.0011)	(0.0008)
# of Observations	1,296,332	1,296,332	1,296,332	1,296,332	1,296,332	1,296,332	1,296,332	1,296,332
Pseudo R2	0.081	0.207	0.103	0.229	0.081	0.205	0.103	0.228
Mean Ret. Rate	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
Mean of OV	9,898	9,898	9,898	9,898	9,898	9,898	9,898	9,898
Std. Dev. of OV	10,110	10,110	10,110	10,110	10,110	10,110	10,110	10,110

Note:
1) Coefficients are marginal effects of a 10,000 unit change in OV from probit models. Standard errors are shown in parentheses.
The effect of a one standard deviation change in OV is shown in brackets (this is estimated as the effect of increasing inclusiv
OV from the current value - 0.5 std. dev to the current value + 0.5 std dev).

Table 2B

Table 2b: Effect of % Gain in Inclusive OV on Retirement				
	Specification			
	(1)	(2)	(3)	(4)
% Gain in OV	-0.2180***	-0.1236***	-0.1836***	-0.0806***
	(0.0018)	(0.0014)	(0.0020)	(0.0015)
Linear Age	X		X	
Age Dummies		X		X
Health Quintiles	X	X	X	X
Other Xs			X	X
# of Observations	1,368,865	1,368,865	1,296,332	1,296,332
Pseudo R2	0.071	0.194	0.099	0.223
Mean Ret. Rate	0.120	0.120	0.120	0.120
Mean of % Gain in OV	0.356	0.356	0.356	0.356
Std. Dev. of % Gain in OV	0.365	0.365	0.365	0.365
Notes:				
1) Models are the same as models 1-4 on Table 1.				
2) Coefficients are marginal effects. Standard errors are shown in parentheses.				

Table 3A

Table 3a: Effect of Inclusive OV on Retirement by Health Quintile								
	# of Obs	Mean Ret. Rate pct.	Mean of OV	Std. Dev. of OV	Specification			
					(1)	(2)	(3)	(4)
OV: Lowest Quintile	273,552	14.363	8,862	9,392	-0.1055***	-0.0798***	-0.0966***	-0.0639***
(Worst Health)					(0.0016)	(0.0014)	(0.0018)	(0.0015)
					[0.0566]	[0.0423]	[0.0499]	[0.065]
	R2				0.045	0.142	0.064	0.161
OV: 2nd Quintile	273,876	12.642	10,095	10,556	-0.0857***	-0.0665***	-0.0722***	-0.0490***
					(0.0015)	(0.0012)	(0.0017)	(0.0014)
					[0.053]	[0.0476]	[0.0405]	[0.0285]
	R2				0.063	0.159	0.087	0.185
OV: 3rd Quintile	273,816	10.524	10,738	11,049	-0.0772***	-0.0510***	-0.0594***	-0.0342***
					(0.0011)	(0.0009)	(0.0015)	(0.0011)
					[0.0673]	[0.0501]	[0.0436]	[0.0256]
	R2				0.104	0.217	0.131	0.246
OV: 4th Quintile	273,827	11.073	9,571	9,960	-0.0800***	-0.0428***	-0.0628***	-0.0282***
					(0.0012)	(0.0008)	(0.0015)	(0.0009)
					[0.0629]	[0.0387]	[0.0418]	[0.0186]
	R2				0.120	0.269	0.144	0.293
OV: Highest Quintile	273,794	11.249	10,217	9,381	-0.0897***	-0.0509***	-0.0765***	-0.0372***
(Best Health)					(0.0011)	(0.0009)	(0.0014)	(0.0010)
					[0.0835]	[0.0487]	[0.065]	[0.0283]
	R2				0.127	0.266	0.147	0.286
Linear Age					X		X	
Age Dummies						X		X
Other Xs							X	X

Notes:

1) Models are the same as models 1-4 on Table 1, but are estimated separately by health quintile; each coefficient on the table is from a different regression.

2) Coefficients are marginal effects of a 10,000 unit change in OV from probit models. Standard errors are shown in parentheses. The effect of a one standard deviation change in OV is shown in brackets (this is estimated as the effect of increasing inclusive OV from the current value - 0.5 std. dev to the current value + 0.5 std dev).

Table 3B

Table 3b: Effect of % Gain in Inclusive OV on Retirement by Health Quintile								
	# of Obs	Mean Ret Rate pct	Mean of % OV	Std. Dev. Of % OV	Specification			
					(1)	(2)	(3)	(4)
OV: Lowest Quintile	273,552	14.363	0.34	0.36	-0.2128***	-0.1310***	-0.1897***	-0.0924***
(Worst Health)					(0.0047)	(0.0039)	(0.0053)	(0.0042)
	R2				0.032	0.127	0.056	0.153
OV: 2nd Quintile	273,876	12.642	0.40	0.44	-0.1851***	-0.1295***	-0.1632***	-0.0931***
					(0.0038)	(0.0031)	(0.0042)	(0.0032)
	R2				0.053	0.146	0.084	0.179
OV: 3rd Quintile	273,816	10.524	0.39	0.36	-0.2043***	-0.1235***	-0.1538***	-0.0744***
					(0.0033)	(0.0026)	(0.0037)	(0.0026)
	R2				0.094	0.204	0.128	0.240
OV: 4th Quintile	273,827	11.073	0.30	0.29	-0.2352***	-0.1155***	-0.1839***	-0.0678***
					(0.0031)	(0.0022)	(0.0037)	(0.0024)
	R2				0.117	0.261	0.145	0.290
OV: Highest Quintile	273,794	11.249	0.31	0.27	-0.2321***	-0.1145***	-0.1930***	-0.0739***
(Best Health)					(0.0036)	(0.0027)	(0.0041)	(0.0029)
	R2				0.118	0.253	0.144	0.280
Linear Age					X		X	
Age Dummies						X		X
Other Xs							X	X
Notes:								
1) Models are the same as models 1-4 on Table 1, but are estimated separately by health quintile; each								
2) Coefficients are marginal effects. Standard errors are shown in parentheses.								

Table 3C

Table 3c: Effect of Inclusive OV on Retirement with health interaction

	Specification			
	(1)	(2)	(3)	(4)
OV_Inclusive	-0.0842***	-0.0492***	-0.0714***	-0.0348***
	(0.0012)	-0.0009	-0.0012	-0.0009
	[0,0643]	[0,0446]	[0,0502]	[0,0263]
Health Index	-0.0003***	0.0002***	-0.0003***	-0.0002***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
OV_Inclusive*Health Index	-0.0001***	-0.0001***	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Linear Age	X		X	
Age Dummies		X		X
Other Xs			X	X
# of Observations	1296332	1296332	1296332	1296332
Pseudo R2	0.081	0.205	0.103	0.228
Mean Ret. Rate	0.119697	0.119697	0.119697	0.119697
Mean of OV	9897.63	9897.63	9897.63	9897.63
Std. Dev. of OV	10109.82	10109.82	10109.82	10109.82

Notes:
1) Models are the same as models 5-8 on Table 1, with the addition of an OV*health index interaction.
2) Coefficients are marginal effects of a 10,000 unit change in OV from probit models. Standard errors are shown in parentheses. The effect of a one standard deviation change in OV is shown in brackets (this is estimated as the effect of increasing inclusive OV from the current value - 0.5 std. dev to the current value + 0.5 std dev).

Table 4A

Table 4a: Effect of Inclusive OV on Retirement By Education Group								
	# of Obs	Mean Ret. Rate pct.	Mean of OV	Std. Dev. of OV	Specification			
					(1)	(2)	(3)	(4)
OV: < High School	428,140	14.2	7,559	7,346	-0.1030***	-0.0659***	-0.1026***	-0.0549***
					(0.0016)	(0.0013)	(0.0021)	(0.0016)
					[0.0605]	[0.0375]	[0.0596]	[0.0266]
	R2				0.058	0.204	0.078	0.227
OV: High School	580,931	12.4	9,576	8,768	-0.0913***	-0.0548***	-0.0863***	-0.0463***
					(0.0010)	(0.0008)	(0.0012)	(0.0009)
					[0.0683]	[0.0417]	[0.0608]	[0.0304]
	R2				0.093	0.219	0.107	0.234
OV: Some College	268,381	8.9	11,798	11,554	-0.0614***	-0.0374***	-0.0595***	-0.0328***
					(0.0010)	(0.0007)	(0.0012)	(0.0008)
					[0.0454]	[0.0292]	[0.0452]	[0.024]
	R2				0.079	0.181	0.097	0.198
OV: College	86,920	4.1	17,979	17,053	-0.0218***	-0.0150***	-0.0191***	-0.0123***
					(0.0006)	(0.0005)	(0.0007)	(0.0005)
					[0.023]	[0.0186]	[0.0186]	[0.0137]
	R2				0.086	0.142	0.104	0.163
Linear Age					X		X	
Age Dummies						X		X
Health Quintiles					X	X	X	X
Other Xs							X	X

Notes:
1) Models are the same as models 1-4 on Table 1, but are estimated separately by education group; each coeffici
table is from a different regression.
2) Coefficients are marginal effects of a 10,000 unit change in OV from probit models. Standard errors are shown
parentheses. The effect of a one standard deviation change in OV is shown in brackets (this is estimated as tl
increasing inclusive OV from the current value - 0.5 std. dev to the current value + 0.5 std dev).

Table 4B

Table 4b: Effect of % Gain in Inclusive OV on Retirement By Education Group								
	# of Obs	**Mean Ret. Rate pct**	**Mean of % OV**	**Std. Dev. of % OV**	**Specification (1)**	**(2)**	**(3)**	**(4)**
OV: < High School	428,140	14.21	0.31	0.31	-0.2269***	-0.1229***	-0.2241***	-0.0935***
					(0.0035)	(0.0027)	(0.0044)	(0.0031)
	R2				0.055	0.199	0.075	0.223
OV: High School	580,931	12.38	0.36	0.34	-0.2182***	-0.1113***	-0.2053***	-0.0861***
					(0.0026)	(0.0020)	(0.0030)	(0.0022)
	R2				0.088	0.209	0.103	0.228
OV: Some College	268,381	8.94	0.38	0.41	-0.1544***	-0.0844***	-0.1419***	-0.0679***
					(0.0032)	(0.0023)	(0.0036)	(0.0025)
	R2				0.074	0.173	0.091	0.192
OV: College	86,920	4.10	0.49	0.61	-0.0537***	-0.0322***	-0.0442***	-0.0246***
					(0.0044)	(0.0033)	(0.0045)	(0.0032)
	R2				0.067	0.121	0.091	0.149
Linear Age					X		X	
Age Dummies						X		X
Other Xs							X	X

Notes:
1) Models are the same as models 1-4 on Table 1, but are estimated separately by education group; each coefficient on the table is from a
2) Coefficients are marginal effects. Standard errors are shown in parentheses.