The Effect of Retirement on Cognitive Functioning in Canada

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Abstract

This study investigates the effect of retirement on cognitive functioning using the National Population Health Survey, a richly detailed Canadian dataset. The longitudinal nature of this survey allows for the correction of individual heterogeneity, while the issue of endogeneity of retirement is handled by exploiting discontinuous, age-based retirement incentives generated by public benefits and private pension systems for the purposes of instrumentation. The results indicate that retirement has a significantly detrimental impact on cognitive functioning, as measured by a respondent's probability of reporting issues with memory or problem solving ability. These findings thus provide support for the mental-exercise hypothesis stating that continued mental stimulation staves off age-related decline in cognitive ability.

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All errors and omissions found herein are my own.

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1 Introduction

Does mental exercise help prevent the decline in cognitive ability associated with aging? Intuitively, this seems to be a reasonable assumption: continued mental stimulation could have the effect of preserving one's faculties over time, while disuse and lack of stimulating activities may lead to atrophy. If this is the case, there are obvious implications from a public policy perspective. First and foremost, encouraging individuals to delay retirement for some years would be advisable, since this could increase the amount of high quality-of-life years available in one's lifespan, and likely serve to reduce the strain on health institutions. Further, legislation that requires individuals to delay retirement could alleviate the impending social security concerns stemming from the rapidly aging population in most industrialized countries. Unfortunately, acceptance of the mental-exercise hypothesis is hardly a *fait accompli*. A review of the psychological literature on this topic conducted by Salthouse (2006) does not find a great deal of support for this conclusion, stating: *"at the present time the mental-exercise hypothesis is more of an optimistic hope than an empirical reality"*.

Given this, it would seem that further approaches, particularly those from the perspective of empirical research, merit consideration. In the spirit of Dave et al. (2008) and Bonsang et al. (2010), this study seeks to determine whether there exists an effect of retirement on cognitive ability. Certainly, the act of retirement itself is not what is of interest here; rather, the lifestyle changes that are brought on by retirement — namely, a less rigid schedule of daily activities, an absence of the mental effort required in employment and a gradual decline in social interactions —

represent the interest of this research. The theoretical backdrop of this study can thus largely be considered that of testing the mental-exercise hypothesis.

Conducting this study in the Canadian context, the National Population Health Survey provides a large, longitudinal sample with data on a great many variables of interest and, due to the time component, allows for the correction of individual-specific, time-invariant heterogeneity. This research also aims to avoid the potentially confounding issue of endogeneity by employing a novel instrumentation strategy and modern econometric methods, thus providing grounds for a causal interpretation of the effect of retirement on late-life cognitive ability.

The remainder of this paper is structured as follows: Section 2 provides an overview of the literature on this research topic, with particular attention paid to identification methods undertaken by previous researchers. Section 3 describes the data as well as the measures of retirement, cognitive function, and other explanatory variables. Section 4 explores the retirement incentives in Canada faced by older individuals as a means to determine a viable identification strategy to use in this study, while Section 5 details the empirical framework. Section 6 presents the results of the study, along with a baseline model and several robustness checks. Finally, Section 7 provides a conclusion to the analysis.

2 Literature Review

In reviewing the expanding literature investigating the impact of retirement on mental health outcomes, two considerations are readily apparent: first, that identification strategies — in particular, those that aim to disentangle the endogeneity of health and retirement — vary widely from study to study; and second, that there exists no clear consensus on the direction of the effects. It appears exceedingly likely that these issues are inherently linked: a study with a less-robust identification strategy may end up with results contrary to another with a clearer display of causality. Some studies, in particular those conducted by Coe and Zamarro (2011) and Rohwedder and Willis (2010) even employ identical datasets and, using somewhat different instrumentation techniques and separate measures of individual health, show mixed and somewhat contradictory results. As identification is of crucial importance for any study on the subject, the forthcoming review will pay special attention to instrumentation methods and other procedures employed by previous researches intended to shed light on the causal impacts of retirement on mental health.

Using a linear probability model in a panel data structure,[1] Neuman (2008) investigates the causal effect of retirement on changes in both subjective and objective measures of health. In an effort to correct for the inherent endogeneity issue, three sets of instruments are tested. The first set involves the generation of dummy variables reflecting the discontinuous age-specific retirement incentives in place in the United States. The second employs a series of dummy variables indicating whether one's spouse has reached one of the aforementioned ages of eligibility for social security incentives. Thirdly, two dummy variables are generated; one indicating whether an individual is past the age of eligibility for their own private pension, and another indicating whether an individual is past the self-reported usual age of retirement

[1] Employing the Health and Retirement Survey.

for their given profession. In each of the cases, Neuman provides robustness tests and convincing argumentation in favour of the exogeneity of the instruments. The results show that subjective health measures are shown to increase by a small but not insignificant amount as a result of retirement, while mental health, measured in this study only by depression, is shown to not have been affected.

Again appealing to panel data methods,[2] Dave et al. (2008) set about finding the effect of retirement on both physical and mental health outcomes. Differently from other authors, Dave et. al. use fixed effects estimation and sample stratification in order to find causal interpretations. Limiting the sample to include only those individuals claiming no important or major health issues prior to retirement, it is asserted that retirement cannot have been a direct result of health concerns, thus resolving any potential endogeneity issues. One potential issue with this strategy, however, is the likelihood that individuals may retire due to sudden health changes.[3] Responding to this criticism, Dave et. al. further limit the sample to individuals who report no change in health between periods, and provide a set of robustness checks including a spousal-retirement IV estimation. Once the issue of period-to-period health change is controlled for, the subsequent estimation methods produce similar results: retirement produces significant and negative impacts on both physical and mental health measures.

The aforementioned analysis of Coe and Zamarro (2011) opts for a different approach, examining the effects of retirement in a multi-country setting. Through the

[2]Also employing the Health and Retirement Survey.
[3]Per Neuman (2008).

use of the European SHARE[4] dataset, this study takes into account potential sources of endogeneity by using cross-country variations in retirement incentives. Here, no significant impact of retirement on mental health, as measured by cognitive ability and depression, is detected. Meanwhile, adopting a similar identification strategy were Rohwedder and Willis (2010), who had also made use of the SHARE dataset and employed a similar econometric specification as Coe and Zamarro. However, the results here do not match that of their counterparts, ultimately indicating that retirement has a significantly negative impact on mental health measures.

Maes and Stammen (2011) study the mental and physical health impacts of retirement through the use of a cross-sectional survey based on the subjective perceptions of general practitioners in Belgium. The study shows that the GPs generally believe that early retirement is an important cause of mental health issues, with depression being highlighted as a primary concern. Physical issues are on the other hand related to issues of adaptation to a new environment post-retirement. While these results are certainly interesting, the small sample of 82 general practitioners, compared to a population in the tens of thousands country-wide, coupled with the subjective nature of the questions, render definitive causal inferences imprudent.

In a very promising piece of research, authors Bonsang et al. (2010) employ a dual approach to identifying the causal effect of retirement on cognitive function, drawing upon two separate estimation procedures in using both the HRS and the European SHARE. Similar to the works of Dave et al. (2008), the HRS portion of this study involves an instrumental variable fixed effect approach, using a set of instruments

[4] The Survey of Health and Retirement in Europe.

involving discontinuous age-specific retirement incentives. The SHARE section, on the other hand, follows a similar estimation procedure as outlined in the Coe and Zamarro (2011) and Rohwedder and Willis (2010) works, with one significant improvement: instead of exploiting cross-country differences in age-specific retirement incentives, Bonsang et. al. use differences in retirement patterns across countries instead, advancing the argument that these better represent the social and statutory incentives involved in retirement and thus form the basis of a more robust instrumentation strategy than any previous studies. The two estimation procedures return surprisingly similar results: a clear and very significant negative effect of retirement on cognitive ability.

Two separate studies by Latif[5] examining, respectively, the impact of retirement on psychological well-being and the impact of retirement on health, make use of the same Canadian dataset employed in the current study.[6] The instrumentation strategies employed within these studies follow that of Neuman and Bonsang et al., which exploit discontinuous variation in eligibility for retirement benefits provided by the federal government. The results from each of these studies show, in turn: (1) that retirement has a significant and positive impact on subsequent self-report psychological well-being, and (2) that retirement has a positive but insignificant effect on self-reported health status. While these results seem to run counter to those found by several authors, notably Dave et al., whom have found significant negative effects on both physical and mental health measures, it is possible that since Latif makes use of a Canadian dataset, these discrepancies may be due to

[5]Latif (2011) and Latif (2012).

[6]The National Population Health Survey (NPHS).

societal and institutional differences present between the United States and Canada. As well, the consideration that any positive effects on psychological well-be]ing[7] may be largely due to the removal of the stresses of day-to-day working life, still applies.

Thus, even with the wealth of research in this field of study in recent years, it is clear that a consensus has not yet been established. While there is a prevalence of research indicating that retirement has a definitive negative effect on mental health, this has not been shown in some recent studies, such as Neuman (2008) and Coe and Zamarro (2011). Further, notwithstanding novel approaches to identification in recent publications, alternate approaches bear consideration.

This study will aim to contribute to the current literature in two important ways: first, by investigating the effect of retirement on late-life cognitive ability in Canada, which, to the author's knowledge, has not yet been done; and second, by employing an identification strategy that exploits the discontinuous nature of the Canadian retirement benefits structure, while simultaneously taking into account the retirement incentives created by private pensions offered by employers.

3 Data

The present analysis relies upon the National Population Health Survey (NPHS), a survey conducted by Statistics Canada. The NPHS collects longitudinal information on the health of the Canadian population along with related socio-demographic information. The target population of the NPHS 'Household' component involves

[7] Measured within Latif (2011) as the respondent's self-reported estimation of their own happiness.

residents in the 10 Canadian provinces selected in the start year of 1994/1995, while excluding several groups from the survey.[8] Each respondent is interviewed every two years, answering a set of questions including those relating to health status, use of health services and determinants of health, as well as socio-demographic information. In particular, there are a number of questions that pertain directly to the phenomenon under study; self-reported measures of cognitive ability and memory, period-to-period changes in health issues, changes in work force status, and relevant socio-demographic factors such as age, education, sex, marital status, and income are all reported. There are, as of this writing, eight waves of the survey currently available, spanning the years 1994/1995 to 2007/2008.

As the population of interest in this study focuses on individuals nearing the retirement phase of their life, the sample is restricted to respondents aged 50-75. It is worthwhile to note that in the case of disability or incapacity to respond to the survey, proxy interviews are conducted when possible. This likely serves to decrease the portion of the sample that fails to respond due to issues of mental health, a very important consideration given the research question at hand.

Since the effect of interest here is that of permanent retirement on cognition, as opposed to partial or temporary retirement, any individual that reports returning to work after initially retiring is dropped from the sample. In the same vein, individuals who report never being in the workforce are not included for the purposes of this study. Further, individuals who fail to report for 4 or more consecutive periods are

[8] Persons living on Indian reserves and Crown lands, health institution residents, Canadian Forces members living on Canadian Forces bases, persons serving out sentences in prison, and residents of certain remote areas in Ontario and Quebec do not figure as part of the sampled population.

omitted. Finally, observations with missing values for pertinent variables are also excluded from estimation. The final sample consists of 8,214 observations for 1,120 individuals.

Descriptive statistics for this sample are presented in Table 1. Most of what is shown here is along the lines of what is expected: men and non-whites appear to have a tendency to delay retirement; stroke, heart disease and other health factors are more prevalent among the retired;[9] and, importantly for this study, retirees show a higher rate of reporting cognitive problems, though not much inference can be drawn from this fact alone.

3.1 The measure of cognitive function

In order to account for changes in mental health and ability to reason over time, the NPHS adopts a self-reported approach, asking each longitudinal respondent to rate their own ability to remember and solve problems. Specifically, each respondent is asked two questions, one each for memory and cognitive ability. The question pertaining to the respondent's memory asks that they describe their usual ability to remember things as being one of the following: *"able to remember most things"*, *"a little forgetful"*, *"very forgetful"* or *"unable to remember anything at all"*. As for the cognition question, the respondent is asked to describe their usual ability to think and solve problems as either: *"able to think clearly and solve problems"*, *"having a little difficulty"*, *"having some difficulty"*, *"having a great deal of difficulty"* or *"unable to*

[9]This is likely due to both the fact that one suffering from these conditions would be more likely to retire, and that the retired population is generally significantly older than the working population.

think and solve problems".

The dependent variable used in this study is constructed based on the above questions, returning a value of '1' if the respondent reports any problems with cognition or memory, and '0' otherwise.

A crucial imputation has been adopted in this study in order to mitigate potential issues of measurement error. Since declines in cognition appear especially likely to cause respondents to fail to be interviewed or otherwise complete the survey for each period, a practice of ascribing the *next reported value* whenever an individual fails to respond for a given period has been employed. While this may appear somewhat contentious, measurement error in the dependent variable is likely only to affect the accuracy of the coefficients and not introduce significant bias,[10] and, of course, such an imputation is likely to reduce said measurement error. To ensure that no potential problems were introduced into the estimation procedures employed later in this paper, a robustness check will involve running the same regressions using the original, non-imputed version of cognitive function.

3.2 The measure of retirement

The measure of retirement employed in this study relies primarily on a respondent's self-reported work status. Respondents reporting being retired are assigned a value of '1' in the retirement dummy variable, and '0' otherwise. In order to ensure the accuracy of this variable, an alternate measure will be employed in order to mitigate the potential issue of measurement error. This will consist of assigning a 'retired'

[10]See Wooldridge (2002).

status to a respondent if three criteria are met: (1) the respondent must not be in the workforce during the reporting period, (2) the respondent must report receiving either some type of government retirement benefit (such as the Canada / Quebec Pension Plan, or Old Age Security) or a private pension as part of their household income, and (3) the respondent meets the relevant age criteria for receiving these benefits; over 60 in the case of the C/QPP, and over 65 in the case of the OAS.

3.3 Other explanatory variables

Other factors that are likely relevant to explaining the cognitive ability of individuals will be included in this analysis. Health factors, proxied by an individual's reporting of having been diagnosed with high blood pressure, heart disease, and stroke, are all included as dummy variables. An age variable will be included in the analysis in order to account for the natural aging effect on cognition. A squared term of age will be included as well, as it appears reasonable that age has a greater negative effect on cognition in the later years of life. A square of "years of education" will also be included, along with controls relating to socio-demographic factors such as sex, race, and whether or not the respondent lives alone.

4 Dealing with Endogeneity: In Search of a Viable Identification Strategy

As alluded to earlier, one of the primary concerns in conducting this study relates to the inherent endogeneity of mental and physical health factors in retirement decisions. As a means to permit proper identification in the subsequent analysis, a valid instrumentation strategy needs to be employed. Unlike prior research that examined the causal impact of retirement on physical health, however, certain strategies do not hold here. For example, Dave et al. employed, as a robustness check against a fixed-effects approach to the elimination of endogeneity, 'spousal retirement' as an instrument for a given individual's own retirement status. Since, when considering cognition specifically, it appears reasonable that both (1) an individual prone to cognitive issues is less likely to have a spouse to begin with, and (2) an individual who has a spouse, through the effect of increased social contact, is more likely to retain their own faculties (and for a longer period of time), this strategy cannot be employed in the current context.

As an alternative, an approach employed by authors Neuman (2008) and Bonsang et al. (2010) attempts to exploit age-based retirement incentives generated by public and private pension instruments. Each of these studies relies on Social Security eligibility in the United States, which occurs in a discontinuous fashion at ages 62, 65 and 70. Since mental and physical decline does not generally occur discontinuously, i.e. decline relating to age does not depend on whether the individual has reached their 62nd, 65th or 70th birthday, while having reached these dates does matter for benefit eligibility, it is thus possible to exploit these incentive structures for the purposes of instrumentation. This assumes of course that the 'age' effect of mental and physical decline is properly accounted for in estimation.

From a Canadian perspective, Latif (2011) adopts a similar identification strategy, making use of age-based retirement incentives inherent in the Canadian benefits system and selecting ages 60, 65 and 70 as benchmarks for benefits eligibility. However, these benchmarks merely indicate the ages at which individuals attain eligibility for certain public benefits; they do not take into account the age-specific differences in the relative amounts of these benefits, nor do they internalize the rather significant effect of private pension plans on retirement incentives.

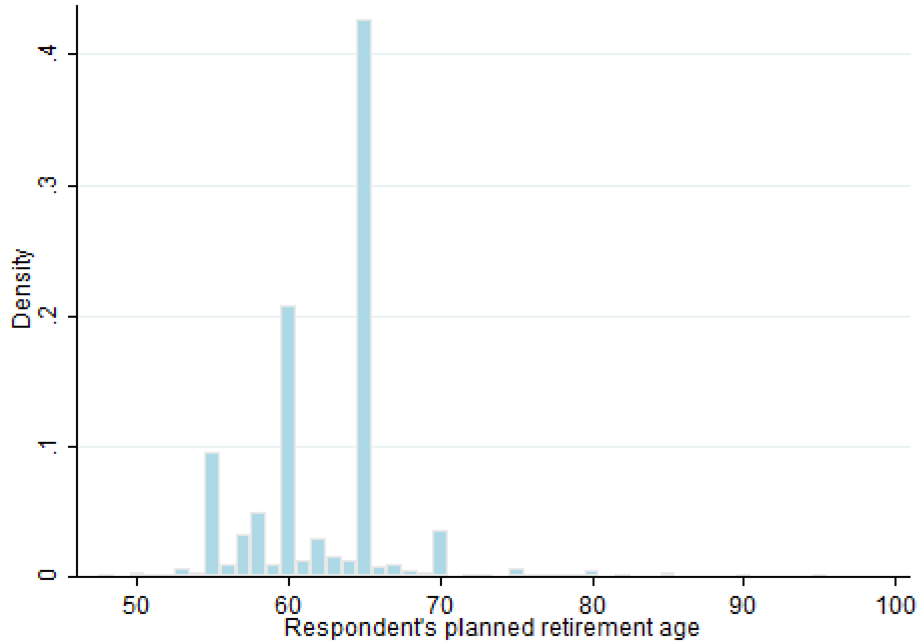
As such, it appears sensible to devote further study into both public and private retirement incentives in Canada in determining the ages at which these eligibilities have the greatest effect on one's propensity to retire, and to observe whether these line up with retirement patterns on aggregate. To this end, an analysis of retirement patterns and public and private retirement instruments follows.

4.1 Retirement Patterns in Canada

The average age of retirement in Canada has varied only slightly over the eight waves included in this study. After following a lengthy downward trend spanning several decades, the average retirement age hit an all-time low of 60.9 years in 1998, before increasing to the range of 61 to 61.5 by the early 2000s where it has since remained relatively steady. Meanwhile, retirement expectations, as evidenced by a 2005 snapshot as part of the Labour Force Survey, display an interesting phenomenon: there are clear spikes in expected retirement at the ages of 60 and 65.

If physical and mental changes associated with age are considered the primary reason for retirement for most Canadians, it seems likely that retirement expectations would follow a smoother, increasing path beyond the age of 60. The spikes at the ages of 60 and 65 shown in Figure 1 can instead likely be attributed to discontinuous

Figure 1: *Retirement Expectations in Canada, 2005 (Statistics Canada)*



changes in age-based retirement incentives inherent in public and private retirement benefits.

4.1.1 Canada's Retirement Income System

In examining retirement incentives generated by Canada's retirement income system, there are two primary government programs to be considered; the Canada Pension Plan (CPP; referred in the province of Quebec as the Quebec Pension Plan or QPP) and the Old Age Security (OAS). In addition to OAS, lower-income individuals are also eligible to receive further benefits, in particular the Guaranteed Income Supplement (GIS), which is aimed at providing a minimum living standard to all adherents.

4.2 The Canada / Quebec Pension Plan

The C/QPP is a contribution-based monthly benefit program paid to all adherents who meet residency requirements and have made at least one contributory payment towards the plan. While the amount of the monthly benefits received is largely reliant on the level of contributions made throughout one's life, a maximum amount of employment earnings is used in calculation. In 1994, the maximum earnings eligible for contribution towards the program was $34,400; in 2008 this figure had risen to $44,900; these amounts are roughly equal in terms of real dollars. These amounts correspond to monthly benefits of $694.44 and $884.58, respectively, upon retirement at the age of 65. Although an adherent will receive the full amount of their benefits at the age of 65, they have the option of retiring early, at a minimum age of 60. The resulting benefits will be reduced by 0.5% per month before that individual's 65th birthday, meaning retiring immediately upon turning 60 would result in a 30% reduction in benefits. Further, adherents may choose to work beyond 65, receiving a 0.5% bonus to future benefits for every month worked after this date, up to a maximum of 30% at the age of 70. While these benefit structures seem to be slanted in such a way as to increase the tendency for individuals to retire later in life and secure greater benefits, it is important to consider these incentives from the perspective of lifetime wealth. Since an individual becomes eligible for benefits at the age of 60, working an extra year means effectively losing one year of benefits. Further, there is also a tradeoff in terms of leisure time in favour of consumption, assuming that each of these are considered to be normal goods. Thus, there are counteracting effects at work; working longer results in higher benefits, while retiring earlier grants benefits earlier and for a longer period of time, while also allowing for greater leisure time. Following Fougere et al. (2009), these incentives result in a disincentive to work after the age of 60.

4.3 Old Age Security

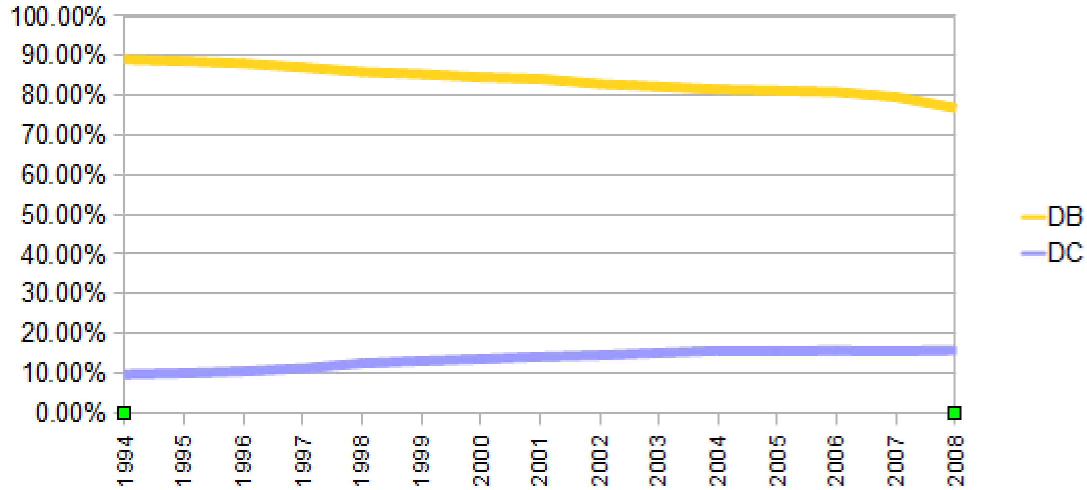
The OAS is offered to all residents aged 65 or older, and is essentially a monthly payment that is of equal size to all those who have lived in the country for a minimum of 40 years before turning 65. There are deductions based on whether a given resident fails to meet these residency requirements, or whether the individual earns above a certain threshold of income. In the former scenario, for every year under 40 years of residency that was not spent within the country, 1/40th of the total benefit is deducted. In the latter case, 15% of excess income above the maximum threshold, excluding the income from OAS itself, is clawed back. The average monthly payment in 2008 was $476.14. Low-income individuals that qualify for OAS are often eligible to receive the Guaranteed Income Supplement (GIS). The GIS offers additional monthly payments to low-income individuals who qualify for OAS and are aged 65 and older. The GIS pays out a full amount to those adherents whom receive a yearly income below a threshold, which decreases incrementally by 50 cents for every dollar earned beyond this amount for individuals, and by 25 cents for every dollar earned by couples. In 2008, the total cutoff amount was $15,240. There exists further government-funded income programs for retirement-age individuals, including the Allowance, which is made available to spouses of OAS recipients who are aged 60 to 64, however there are relatively few adherents nation-wide. For the purposes of this analysis, and considering that these would likely have only marginal impacts on retirement incentives, these will be ignored. Taken together, the OAS and GIS represent strong incentives for withdrawal from the workforce at the age of 65.

4.4 Registered Pension Plans

Registered pension plans (RPPs) are a form of trust that provides pension benefits to employees of a company upon retirement. Over the course of the eight waves included in the study, the proportion of Canadian workers adhering to some form of RPP has remained relatively stable; with 34.7% in 1995 and 32.4% in 2010 being covered. The incentives for early retirement generated by these plans vary significantly among individuals and employers, however a simplifying distinction can be made between two classes of plans: Defined Benefit (DB) and Defined Contribution (DC) plans. In terms of overall adherence to each of these types of plans, DBs have historically been much more prevalent than DC plans in Canada. In 1994, roughly 89% of all registered pension plans offered by employers were of the DB variety, though this has decreased somewhat to 78% by 2008.

DB plans are of particular interest as they generate age-related incentives to retirement. These plans involve according a retirement income to an adherent that is adjusted based on certain factors, including length of tenure at the company and salary. The salary component is often assessed as an average of the individuals highest-earning years at the company or as an average of the last several years of work prior to retirement. As well, penalties may be accorded depending on whether the individual chooses to retire early, before reaching the predefined retirement age

Figure 2: *Registered Pension Plans by Number of Adherents, 1994-2008 (Statistics Canada)*

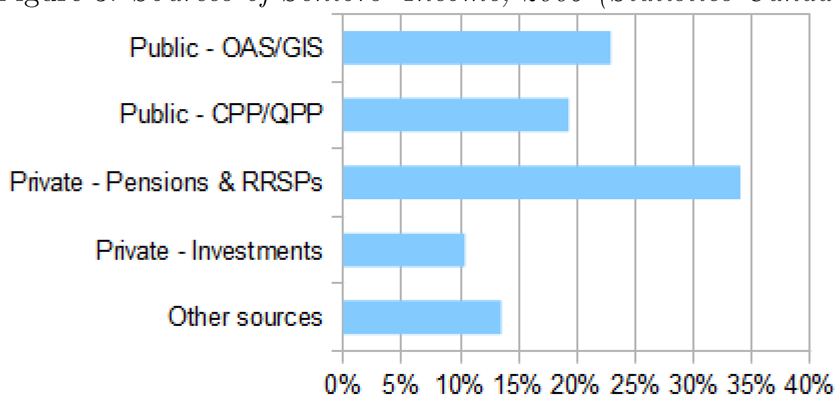


or obtaining the required number of years of tenure. Therefore it is quite likely that DB retirement programs generate age-based incentives to retirement Fougere et al. (2009). DC plans, conversely, do not generate such aged-based incentives. These are funded by contributions made by employees and employers and pay out based on the total amount contributed and the overall performance of the related investments. Amounts payed out during retirement are thus not tied to specific retirement ages; the effect such plans have on the retirement decision are based on amount of post-retirement income available and not specifically due to certain ages reaping increased benefits, as in the case of the DB-type plans.

4.5 Investments and Other Incomes Post-Retirement

Investments and other retirement income instruments are unlikely to generate age-specific incentives for individuals to retire. This is because the amount of income generated by these instruments relies largely on the amount of contributions made by individuals and the performance of the investments over time. While these incomes would certainly affect retirement incentives through a wealth effect, it seems unlikely that these incentives would vary according to an individual's age. Further, according to data produced by Statistics Canada,[11] investments and other non-public, non-employer-based instruments account for only a relatively small portion — less than 25% — of retiree income; see Figure 3. Thus, for the purposes of this analysis, these retirement instruments are left out of consideration.

Figure 3: *Sources of Seniors' Income, 2009 (Statistics Canada)*



4.6 Summary of age-based retirement incentives

The above analysis has shown that there indeed exists age-based retirement incentives in both public and private retirement pension plans. The C/QPP both create strong incentives to retire starting at the age of 60, while OAS and GIS create additional incentives at the age of 65. Private pensions, specifically those of the Defined

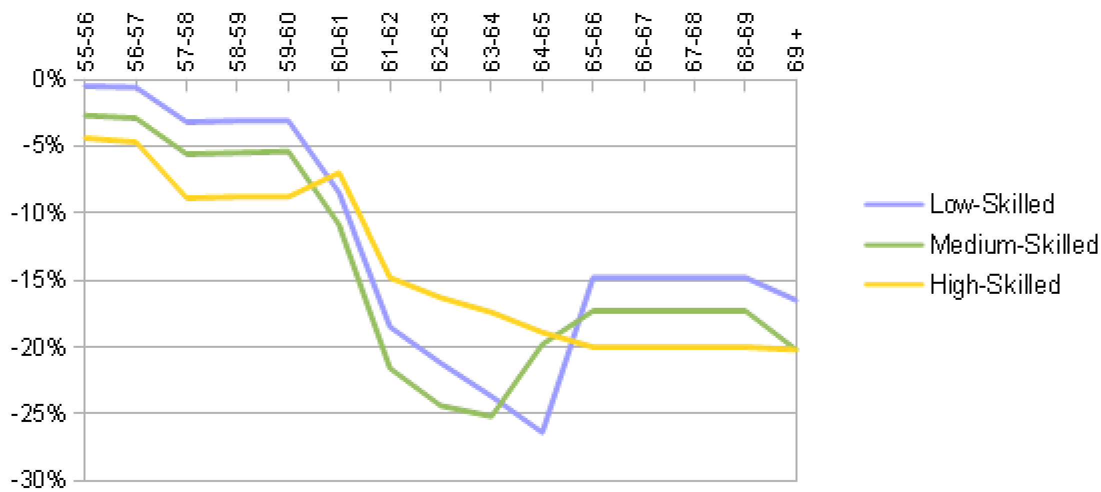
[11]Per the 2005 edition of the Labour Force Survey.

Benefit variety, also create significant retirement incentives at certain ages. While they vary in terms of implementation, it is safe to assume that for those individuals who attain maximum eligibility at an age prior to 65, a great incentive to retire is apparent. Defined Contribution plans and other retirement income instruments do not depend on age and therefore are not likely to generate age-based retirement incentives. Since public pensions and supplements and private pension plans account for over 75% of retirement income on average, it is further more likely that these income sources comprise the primary financial incentive structures for potential retirees. Analyzing these incentive structures in a pragmatic fashion however is not necessarily a straightforward exercise. While I have established based on the above that retirement incentives are apparent at or before the age of 65, and disincentives to work begin to increase markedly at the age of 60, an empirical approach could shed some light as to the level of the impacts that each of these benefits have on retirement propensity. As such, I defer to the work of Fougere et al. (2009), who have, employing an implicit tax rate approach first developed by Stock and Wise (1990), derived empirical estimates of the effect of early retirement incentives generated by both public and private pension plans in Canada using data from the 1999 Survey of Financial Security.[12] The results of this analysis are summarized in Figure 4, where implicit tax rates for representative low, medium, and high-skilled workers are listed by age. Here, progressively lower values indicate increasing disincentives to work.

In analyzing the above figure, it is apparent that individuals face increasing disincentives to work through the ages of 60 to 65, and that these disincentives reach

[12] A survey conducted by Statistics Canada (1999).

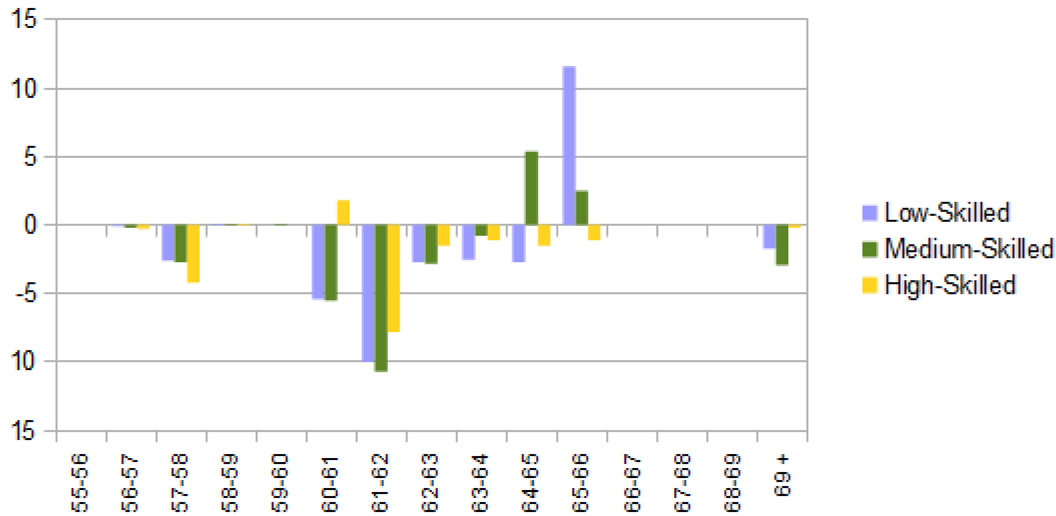
Figure 4: *Average Implicit Tax Rate, Public and Private Pensions; Fougere et al. (2009)*



Note: The implicit tax rate is calculated as the difference in pension wealth if retirement occurs at age 'x' and at age 'x-1', divided by earnings at age 'x-1'

a maximum at the age of 65. This is in accordance with the social security benefits structures explained above; once an individual reaches 65 years of age, assuming they meet all other necessary criteria in terms of years of work within Canada, they become eligible for the Old Age Security, and thus gain access to an additional income stream. However, instead of conceding that since Canadians become eligible for C/QPP at the age of 60, and that disincentives to work begin to increase at this point, that this age must necessarily stand out as the age at which individuals are most likely to retire due to financial reasons, it is worthwhile to determine at what point Canadians face the greatest *increase* in disincentives to work based on implicit tax rates. To shed some light on this, Figure 5 lists the changes in average implicit tax rate based on an individual's age from year to year.

Figure 5: *Changes in the Average Implicit Tax Rate, Public and Private Pensions; Fougere et al. (2009)*



It can now be seen that, while disincentives to work begin to increase rapidly at age 60, potential retirees face the greatest increase in disincentives to work at the age of 61. This result occurs due to the inclusion of private benefits into the equation: according to Fougere et al., disincentives to work created by these benefit structures reach a maximum at the ages of 61-64, and remain relatively constant afterwards. Once these effects are combined with the incentives generated by the public income security system, age 61 stands out as being the point where the greatest financial disincentives to continue working are faced.

4.7 Identification Strategy Implications

Taking into consideration that both retirement expectations, as evidenced by the 2005 Survey of Financial Security, and research completed by Fougere et al. that quantitatively analyzes the effect of public and private retirement programs have on retirement incentives, strongly indicate the ages of 61 and 65 as points where the retirement hazard increases significantly, it seems reasonable to exploit these in order to instrument for retirement. In so doing, the prior effect of mental and physical health on the retirement decision is removed from the equation, and identification becomes possible.

5 The Empirical Model

The objective of this study is to determine whether retirement has an effect on a measure of cognitive ability, after controlling for all relevant factors. A simple, "naive" *pooled ordinary least squares* version of this model, which largely ignores the panel structure of the data, could be estimated as follows:

$$C_{it} = X_{it}\beta_1 + R_{it}\beta_2 + u_{it} \tag{1}$$

Where C_{it} represents a measure of cognitive ability,[13] X_{it} a vector of controls (physical health factors, age, education, social contact and so on), R_{it} a dummy variable indicating whether or not a given individual is retired, and the random, zero-mean error u_{it}. Subscripts i and t respectively refer to individuals and time periods.

Identification in this case, however, is not quite so straightforward. In particular, there are two issues that need to be dealt with in order to obtain at least a consistent estimate of β_2 in equation (1).

[13]This is a binary variable, returning a value of '1' if the respondent reports having problems with memory or cognition, and '0' otherwise. The estimation is thus that of a Linear Probability Model.

Primarily, there exists the inherent issue of endogeneity of the retirement decision to cognition; that is, the R_{it} is expected to be correlated with unobserved factors in the error term u_{it}, i.e. $Corr(R_{it}, U_{it}) \neq 0$. Intuitively, it is reasonable to think that individuals who begin to develop issues with memory or their ability to reason are more likely to exit the workforce and retire. If this phenomenon indeed exists, it is likely that the coefficient on the retirement variable R_{it} would be biased upward. If, on the contrary, individuals who begin to develop memory or cognition issues are instead motivated to remain in the workforce longer as a means to ensure their household has enough wealth to pay for doctor consultations or medications during retirement, then the coefficient may be biased downwards. Regardless, it is reasonable to believe that for the purposes of this study, the simple pooled OLS environment will not be sufficient. Now taking into consideration that the retirement variable is endogenous to cognition, equation (1) can be rewritten as the following system of equations:

$$C_{it} = X_{it}\beta_1 + R_{it}\beta_2 + u_{it} \tag{2}$$

$$R_{it} = X_{it}\theta_1 + C_{it}\theta_2 + W_{it}\theta_3 + v_{it} \tag{3}$$

Where equation (3) represents the factors affecting the individual's retirement decision, and W_{it} is a vector of variables explaining the retirement decision but not affecting cognition. Substituting equation (2) into (3) obtains the reduced-form equation describing the retirement decision:

$$\begin{aligned}
R_{it} &= X_{it}\theta_1 + (X_{it}\beta_1 + R_{it}\beta_2 + u_{it})\theta_2 + W_{it}\theta_3 + v_{it} \\
R_{it}(1-\beta_2\theta_2) &= X_{it}(\theta_1 + \beta_1\theta_2) + u_{it}\theta_2 + W_{it}\theta_3 + v_{it} \\
R_{it} &= X_{it}\frac{\theta_1 + \beta_1\theta_2}{1-\beta_2\theta_2} + W_{it}\frac{\theta_3}{1-\beta_2\theta_2} + u_{it}\frac{\theta_2}{1-\beta_2\theta_2} + v_{it}\frac{1}{1-\beta_2\theta_2} \qquad (4) \\
\Rightarrow R_{it} &= X_{it}\Theta_1 + W_{it}\Theta_2 + u_{it}\Theta_3 + v_{it}\Theta_4 \qquad (5)
\end{aligned}$$

where the Θ indicate the reduced-form parameters given in (4).

In estimating this reduced-form equation, finding exogenous variables W_{it} that themselves do not directly affect cognition, is essential. Following the instrumentation strategy outlined in section 4, the W_{it} here refer to the age-based discontinuous retirement incentives generated by private pensions and Canada's retirement income security system. For these instruments to be valid, the key identification condition is that $\Theta_2 \neq 0$; that is, they must be correlated with retirement behaviour, and, additionally, not correlated with the error term.

Employing *two stage least squares* estimation methods, the following structural equation for the determinants of cognition results:

$$C_{it} = X_{it}\beta_1 + \hat{R}_{it}\beta_2 + u_{it}$$

where $\hat{R}_{it}$ indicates the instrumented retirement variable.

A secondary issue which may confound the estimates of the coefficients is that of unobserved individual heterogeneity. An individual's retirement behaviour and cognitive ability may both be related to time-invariant, individual-specific factors; specifically, retirement behaviour can be affected by one's preferences between present and future consumption, while cognitive ability is likely to be affected by genetics. More concretely, assuming the existence of these time-invariant factors, the error terms u_{it} and v_{it} in equations (2) and (3) may be rewritten as $u_{it} = \gamma_i + \epsilon_{it}$ and $v_{it} = \nu_i + \xi_{it}$, respectively, where γ_i and ν_i represent the unobserved time-invariant factors, and ϵ_{it} and ξ_{it} each represent the zero-mean random error in the cognition and retirement equations, respectively.

Thus, equations (2) and (3) can now be rewritten as:

$$C_{it} = X_{it}\beta_1 + R_{it}\beta_2 + \gamma_i + \epsilon_{it} \tag{6}$$

$$R_{it} = X_{it}\theta_1 + C_{it}\theta_2 + W_{it}\theta_3 + \nu_i + \xi_{it} \tag{7}$$

with the reduced-form equation for retirement now being:

$$R_{it} = X_{it}\Theta_1 + W_{it}\Theta_2 + (\gamma_i + \epsilon_{it})\Theta_3 + (\nu_i + \xi_{it})\Theta_4 \tag{8}$$

Of course, the panel data context of this study allows for the controlling of the issue of unobserved heterogeneity through the use of fixed effects methods. Using *fixed effects two stage least squares* estimation, the final model, with unobserved fixed effects omitted, is:

$$C_{it} = X_{it}\beta_1 + \hat{R}_{it}\beta_2 + \epsilon_{it} \tag{9}$$

and the structural estimate of R_{it} on cognition can now be consistently estimated.

5.1 In Defence of the Linear Probability Model

The primary model choice in this study is therefore that of a fixed effects, instrumental variable *linear probability model.* While it is true that the drawbacks of the linear probability model have been well-documented in the literature, in particular due to the possibility of fitting probabilities outside the [0,1] bounds, I opt for this for several reasons. First, this specification type may be more robust than probit estimation in the face of specification error. Further, according to Neuman (2008):

> *"The problem with the IV probit technique (...) lies in the fact that the dummy variable for retirement choice enters into the model rather than the predicted probability of retirement. Once the predicted likelihood of retirement is used to instrument the retirement decision in the IV estimation procedure the error term is no longer normally distributed, making probit estimation inappropriate and leading to inconsistent results."*

The same argument holds here as it is also a binary retirement choice that is used in the two stage least squares estimation, and not the probability of retirement. It has also been posited that, for a limited dependent variable model where all of the right hand side variables are binary[14] the linear probability specification estimates the conditional mean *perfectly*, and is thus superior to its usual alternatives.[15] Finally, an added benefit of employing this estimation type is that the marginal effects of the variables in question can be readily observed through the regression output, and one need not rely on *average marginal effects* for the purposes of inference.

[14] Here, all except the 'age' terms are binary variables.

[15] Angrist (2006).

6 Results

Employing the methods outlined in the previous section, two sets of regression outputs have been produced. First, a "naive" *pooled OLS* model is estimated following the specification described in Equation (1) as a means to provide baseline results. This model is run with both a self-reported retirement variable as well as an imputed retirement variable. Second, the *instrumental variable fixed effects* model described by Equation (9) is estimated, again using both measures of retirement. The following subsections discuss the results from each of these estimations.

6.1 Pooled OLS Baseline Model

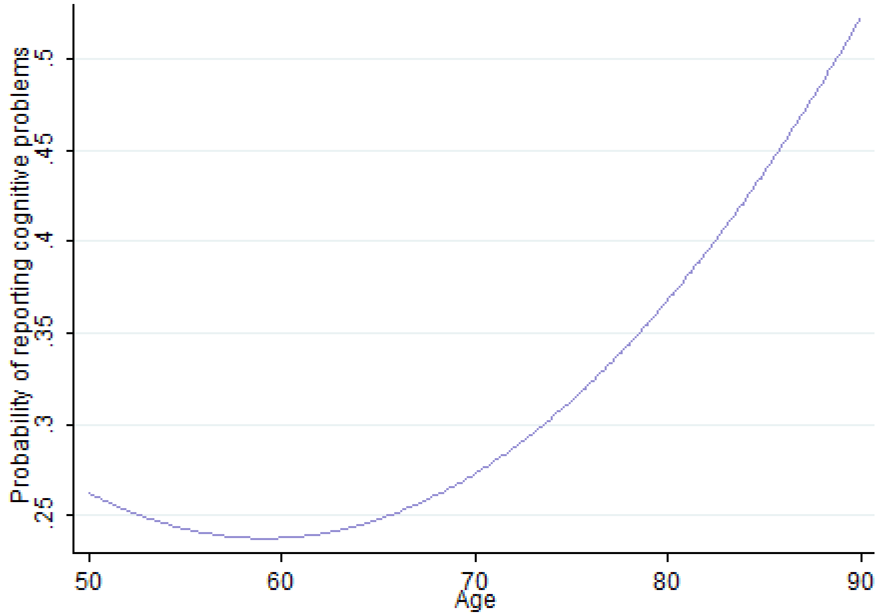
The results of the *pooled OLS* baseline model are presented in column (i) of Table 2. Included in this regression are a number of covariates, covering measures physical health and socio-demographic characteristics. For the most part, the coefficients on the control variables have the expected signs: measures of poor physical health such as heart disease cause an increased probability in the respondent reporting cognitive issues.[16] Age is a quadratic function with a turning point around the age[17] of 58, so that respondents over this age are increasingly likely to report cognition issues; this adequately captures the natural, detrimental "age-effect" on cognition.

Progressively higher years of education lead individuals to be less likely to re-

[16]The 'high blood pressure' variable has this effect as well, however is only significant at the 10% level in the regression that uses the self-reported definition of retirement

[17]It is worthwhile to note that while the 'Age' variable returns a negative coefficient, the constant in the regression is positive and well above 1. Since all respondents are over the age of 50, the interaction with the age coefficient is essentially to indicate that people between the ages of 50 and 57 are less likely to report cognition issues, while those age 58 or above are increasingly likely to report such problems. For clarity, Figure 6 details the progression of the effect of age.

Figure 6: *Age effect on Cognition, POLS estimation*



Note: The constant term in the POLS regression is included as an intercept in this calculation.

port cognition problems. This may be partly explained by the findings of Grossman and Kaestner (1997), who show that education makes individuals more efficient in producing health; the same may apply for mental health. Intuitively, more highly-educated individuals may simply be more likely to engage in mentally-stimulating activities, which may serve to help preserve their mental health stock. Meanwhile, the effect of stroke on cognition is as expected: those respondents who report suffering a stroke have a greatly increased probability of reporting issues with their cognitive ability.[18] Of the remaining socio-demographic characteristics, the effects of the 'female' and 'single household' variables are insignificant and centered around zero, and non-whites appear to have a higher propensity to report cognitive problems

[18]This agrees with research conducted by Patel et al. (2002).

but the effect is not statistically significant at the 10% level.

Regarding the retirement variables, a peculiar pattern develops: while being retired for a period of 0 to 4 years yields an increase in the likelihood of a respondent reporting problems with cognition, and being retired for 10 or more years yields a quantitatively higher increase, the results show that being retired for between 5 and 9 years has a statistically insignificant effect at the 10% level, and, while positive, the effect is quantitatively lower than being retired for a period of 0 to 4 years. This counterintuitive result may be due to the aforementioned possibility of measurement error in the self-reported retirement variable. Due to nuances in the National Population Health Survey, respondents may inaccurately report themselves as not being retired. For instance, there are a fair amount of cases where a respondent reports (1) not being in the workforce, (2) being a recipient of some type of retirement benefit, and (3) being over the age of eligibility for such benefits, and does not report themselves as being retired. As the present analysis is primarily concerned with the effects of retirement in terms of the lifestyle changes it causes,[19] the important issue here is whether the respondent had actually worked in the past,[20] and has ceased doing so permanently, regardless of how they define their own working status. It is thus reasonable to assign the 'retired' status to individuals meeting these three criteria.

The results of an identical regression with the the imputed measure of retirement in place of the self-reported measure are reported in column (ii) of Table 2. Here,

[19] As discussed in section 1

[20] As discussed in section 3.2, those who report never being part of the workforce are dropped from the sample; therefore it is safe to assume that all respondents have worked at some time prior to permanently retiring.

the number of years of retirement have the expected progression, and in each case the coefficients are significant at the 1% level. While not providing direct evidence of measurement error, it is worthwhile to note that the coefficient estimates in the self-reported case are each lower and less significant than in the imputed case, which would be expected if measurement error were present in the former scenario, as measurement error in independent variables tend to bias coefficient estimates toward zero.[21] Aside from the increased significance in the effects of retirement, the physical health and sociodemographic controls return very similar estimates as in the first regression.

6.2 The Instrumental Variable Fixed Effects Model

As described in explicit detail in section 5, the estimates obtained by the pooled OLS specification are likely to suffer from bias due to endogeneity and time-invariant individual heterogeneity. To remedy these issues, the IV-FE model represented by equation (9) can be estimated, using the age-based benefit incentive instruments described earlier. It should be noted that due to the nature of the fixed-effects environment, time-invariant socio-demographic variables that had been previously employed in the pooled OLS specification such as education, gender and race cannot be included here.

Subsections 6.2.1 and 6.2.2 discuss, in turn, the validity of the instruments used in estimation and the results of the IV-FE procedure.

[21] Per Hyslop and Imbens (2001).

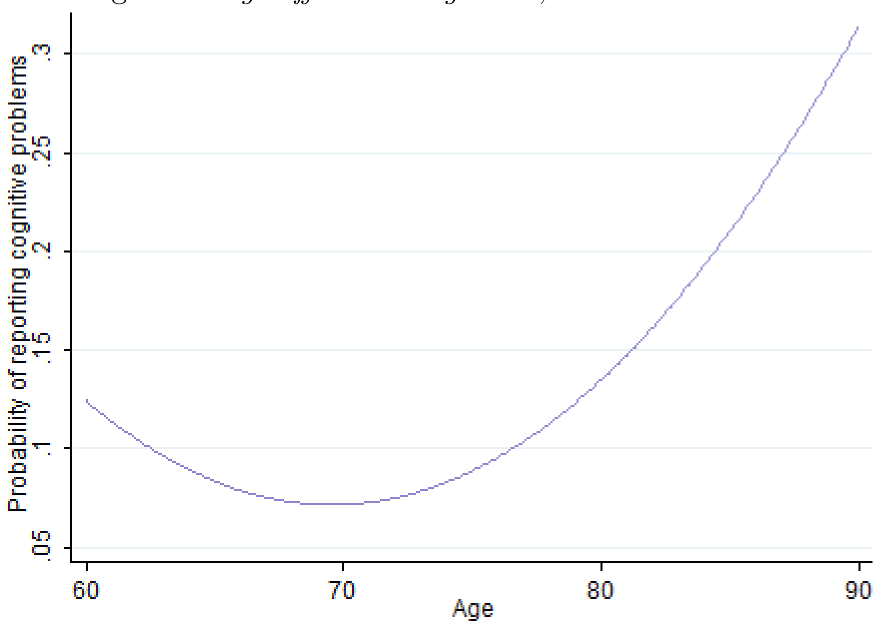
6.2.1 Validity of Age-Specific Retirement Incentives as Instruments for Retirement

Columns (i) and (ii) of Table 3 report the parameters of the first-stage regression explaining the retirement decision for each measure of retirement. In both cases, the instruments adopted in each estimation return very significant, and quantitatively large, effects on the retirement hazard. The test of joint significance of the age-incentives instruments support their use as such, returning χ^2 statistics of 171.09 and 85.27, respectively. Further, the Sargan test of overidentifying restrictions fails to reject the null hypothesis that the instruments are valid. Given all of this, there is little cause for concern as to the legitimacy of the use of age-specific retirement incentive variables as instruments.

6.2.2 IV-FE Results

With the validity of the proposed instruments properly investigated, I now proceed to estimate the instrumental variable fixed-effects regression. Columns (i) and (ii) report the results of these estimations. Included as covariates are a set of health-related dummy variables equaling one if the respondent reports having been diagnosed with heart disease, stroke, or high blood pressure. Of these, only the heart disease variable shows having a significant detrimental impact on cognitive function: respondents reporting having been diagnosed with some form of heart diseases causes a 5% increase in the probability of a respondent reporting issues with cognition. Being diagnosed with high blood pressure does not have a significant effect, though it is possible that the explanatory power of high blood pressure is being affected by the inclusion of heart disease in the regression, and it is likely that these covariates are significantly correlated. Living in a single household also does not appear to have a significant impact on the dependent variable. Meanwhile, the effect of age on cognition is similar to that in the POLS case, however the turning point now occurs toward the age of 66; Figure 7 presents the progression of this effect.

Figure 7: *Age effect on Cognition, IV-FE estimation*



Note: The constant term in the IV-FE regression is included as an intercept in this calculation.

The one surprising result in terms of the controls employed in these regressions are the coefficients on the 'Stroke' variable, which are both positive and highly insignificant. This runs contrary to prior research which has shown that individuals suffering from the effects of a stroke are more likely to have problems with their cognitive ability,[22] and is also in contrast with the initial POLS regression which assumed the exogeneity of retirement.

[22]Patel et al. (2002).

Most interestingly, however, the effect of retirement is shown to have a statistically significant and large detrimental effect on cognition. Depending on the measure used, retirement causes either a 15% or 23% increase in the likelihood of a respondent reporting problems with cognitive function. The differences between these reported coefficients may be due to the issue of measurement error, similar to that which was discussed in section 6.1; if this issue were to exist in the non-imputed retirement variable, this could explain why the coefficient is closer to zero.

Overall, the findings with regards to the effect of retirement on cognition agrees with the results of a number of previous studies, including those conducted by Bonsang et al. (2010), Dave et al. (2008) and Rohwedder and Willis (2010).

6.3 Robustness Checks

The dependent variable, as discussed in 3.1, used in all previous regressions has been an imputed version wherein missing values had been replaced with the *next reported value* where possible. While this has probably served, given the context, to decrease measurement error, it seems reasonable to test the final regression in 6.2.2 using the original, non-imputed dependent variable. Table 5 presents the results of this estimation, including results for both measures of retirement. Comparing the coefficient estimates to those with the imputed cognitive function dependent variable, there are no significant differences to report: retirement still shows a positive and significant effect on the probability of a respondent reporting cognitive problems; age now has a turning point at the age of 65; heart disease is still shown to have a detrimental effect, and the other controls remain insignificant. It is interesting to note however that the coefficient estimates returned in the imputed cognition regression have generally higher p-values than those in the non-imputed regression, which is indicative (though not direct proof of) of there having been an issue of measurement error in the latter estimation, since the effect of measurement error in a dependent variable is, under certain assumptions,[23] to increase the error variance. Given these results, the potentiality of the introduction of bias or inconsistency into the regression through the imputation method outlined earlier is not especially concerning.

Now, to offer further evidence of the robustness of the results shown in Table 4, I employ an alternate regression method that does not make use of the instrumentation methods discussed throughout this paper. More concretely, I follow the specification advanced by Dave et al. (2008) which employs fixed-effects methods on a subset of the sample whom are relatively certain to not have retired due to issues of mental health.

Specifically, any respondent who meets any of the following criteria: (1) reporting physical or mental health issues prior to retirement, (2) reporting such issues in the first period of their retirement or (3) indicates a change in health status between retirement and the last period spent working, are dropped from the sample. Thus, any retirement decision taken by an individual is not likely to be motivated by health reasons, and this should theoretically alleviate the issue of endogeneity.[24] If this is

[23]Notably, that the measurement error in the dependent variable is uncorrelated with the regression error term, which seems reasonable in this scenario. It is also worth mentioning that even without the use of an imputed cognitive function variable, the estimates returned in Table 5 would be consistent.

[24]It should be noted however that since Dave et al. (2008) could appeal to a broader category of controls in the Health and Retirement Survey (2006), such as reported *reason* for retirement, this sample truncation may not be quite as exact.

reasonable, then the effect of retirement on cognitive function could be observed directly. The results of this regression are presented in Table 6, using both the imputed version of cognitive function and the non-imputed version.

Reviewing the results of this alternate specification, it is apparent that these largely are in agreement with that which has been shown previously. Retirement is shown to have a positive and significant effect on a respondent's likelihood of reporting issues with cognition, though it is quantitatively smaller than previously shown. Heart disease indicates a positive and significant effect as well, and returns a larger coefficient in this specification. Stroke and living in a single household are both, again, not significant in explaining the dependent variable. Perhaps the only additional counterintuitive result here is the weakly significant and relatively small effect of having high blood pressure: column (i) shows that this variable actually decreases the likelihood of a respondent reporting cognitive problems.

Taken together, these robustness checks provide a good deal of assurance that the results obtained in the specification outlined in section 6.2.2 are indeed reliable.

6.4 Alternate Estimation Methods

In ensuring that the estimates given by the *IV-FE* model do not come about due to artifacts of the linear probability model type, it seems logical to see if similar results are obtained through maximum likelihood estimation of a set of non-linear models for panel limited dependent variables. To this end, three further model types are employed: *random effects probit*, *random effects logit*, and *fixed effects (conditional) logit*. In each case, the first-stage reduced form regression is estimated separately, with the fitted values being included in the second-stage structural regression as instruments.[25]

The estimates from the *random effects probit* and *random effects logit* are given in Table 7, with the estimated *average marginal effects* listed in Table 8. Since random effects estimations assume that the regressors are not correlated with the error term, and I have already argued that this is not the case due to the issue of individual heterogeneity, it is likely that some bias[26] may exist in the coefficient estimates. It is uncertain, however, in which direction this potential bias would affect these coefficients, as individual heterogeneity may plausibly overstate or understate the effects of the variables on cognition. With that said, examining the average marginal effects in Table 8, the probit and logit models indicate that retirement increases the probability of individuals reporting problems with cognition by roughly .061 and 0.036, respectively; while these estimates are quantitatively smaller, the effect is in the same direction as the previous results. Further, heart disease is shown to increase the probability of cognitive issues by roughly 0.05 in each estimation, which is also similar to the prior estimates.

Turning now to the results of the *fixed effects logit* specification, the model estimates are displayed in Table 9, and Table 10 lists the odds ratios. Since this procedure uses fixed effects methods, and thus accounts for time-invariant individual heterogeneity, these results can be relied upon perhaps more confidently than the random effects models. Again, the effect of retirement on the probability of re-

[25] As a result, the two stages are not estimated simultaneously, and the resulting standard errors are unreliable.

[26] As $Corr(X_t, U_t) \neq 0$

porting cognitive difficulties is shown to be positive; according to the odds ratios, retiring leads one to be 1.312 times more likely to report such issues. Heart disease once again shows a detrimental effect on cognition; here, being diagnosed with heart disease increases the probability of reporting cognitive problems by 1.43 times. The effects of stroke and high blood pressure do not appear to be different from zero, which is also in agreement with the results of the linear probability model.

Seeing that each of the *random effects probit*, *random effects logit*, and *fixed effects logit* specifications obtain results very similar to that of the final model outlined in section 6.2.2, concerns about the choice of the linear probability model estimation method are largely alleviated, and the estimates obtained do not appear to have resulted from quirks of LPM estimation.

7 Conclusion

Employing Canadian data from the National Population Health Survey, this research has consisted of rigorous empirical analysis on the effects of retirement on cognitive functioning. After dealing with the potentially confounding issue of endogeneity and simultaneous causality, and mitigating the issue of unobserved time-invariant individual heterogeneity, the results show a significant detrimental impact on cognitive functioning, as measured by an individual's likelihood of reporting problems with memory or problem solving ability. This effect is also shown when adopting a sample stratification approach as advanced by Dave et al. (2008); i.e., by omitting all individuals who report problems with health or cognition prior to retirement, and estimating the effect of retirement directly. Furthermore, the results are relatively consistent across several different estimation methods, including random effects probit, random effects logit, and fixed effects logit.

As this is, to the author's knowledge, the first study conducted on the effects of retirement on cognitive function in Canada, there are no studies with which the results can be compared directly. However, the main result of this analysis — that retirement has a detrimental impact on cognitive function — is in accordance with several studies conducted in other countries: Bonsang et al. (2010), Dave et al. (2008), Maes and Stammen (2011), and Rohwedder and Willis (2010) all find a negative impact of retirement on mental health, although identification methods and measure of cognitive function vary across these studies.[27]

From a theoretical standpoint, the results of this study seem to be in favour of the mental exercise hypothesis discussed in detail within Salthouse (2006). Taking as granted that working involves continued cognitive effort, a causal relationship has been shown that ceasing work, and the associated cognitive effort, results in worse mental health outcomes. It is important to note however that not all types of work are equal. Further study is merited in order to determine if retiring from intellectually-stimulating employment has a differing effect on cognition than retiring from a less mentally-intensive line of work.[28]

Considering the implications from a public policy perspective, these results are suggestive of measures that may encourage individuals to delay retirement for some years, as this would have the dual benefit of reducing the strain on the public financ-

[27]Using, respectively: European and American data, American data, Belgian data, and European data.

[28]Bonsang et al. (2010) reach a similar conclusion.

ing of the Canada Pension Plan and likely decreasing healthcare costs for seniors due to the mental-health-preserving effect of continued work.[29]

[29] These findings are, coincidentally, in line with recent changes to the Canada Pension Plan that penalize individuals more significantly for retiring before the age of 65.

A References

Angrist, J. D. (2006). Instrumental variables methods in experimental criminological research: what, why and how. *The Journal of Experimental Criminology 2*, 23–44.

Bonsang, E., S. Adam, and S. Perelman (2010). Does retirement affect cognitive functioning? *Maastricht: ROA, Research Centre for Education and the Labour Market* (Research Memoranda 001), 1–44.

Coe, N. B. and G. Zamarro (2011). Retirement effects on health in europe. *Journal of Health Economics 30*, 77–86.

Dave, D., I. Rashad, and J. Spasojevic (2008). The effects of retirement on physical and mental health outcomes. *Southern Economic Journal 75*(2), 497–523.

Fougere, M., S. Harvey, Y. Lan, A. Leonard, and B. Rainville (2009). Incentives for early retirement in canadas defined-benefit public and private pension plans: An analysis with a dynamic life-cycle cge model. *Retirement Policy Issues in Canada*.

Grossman, M. and R. Kaestner (1997). The effect of education on health. In J. R. Behrman and S. G. Nevzer (Eds.), *The social benefits of education*, pp. 69–123. University of Michigan Press.

Hyslop, H. R. and G. W. Imbens (2001). Bias from classical and other measurement error. *Journal of Business & Economic Statistics 19*(4), 475–481.

Latif, E. (2011). The impact of retirement on psychological well-being in canada. *The Journal of Socio-Economics 40*, 373–380.

Latif, E. (2012). The impact of retirement on health in canada. *Canadian Public Policy 38*(1), 15–29.

Maes, M. and B. Stammen (2011). The impact of (early) retirement on the subsequent physical and mental health of the retired: a survey among general practitioners in belgium. *HUB Research Paper, Economics & Management*, 1–8.

Neuman, K. (2008). Quit your job and get healthier? the effect of retirement on health. *Journal of Labor Research 29*, 177–201.

Patel, M. D., C. Coshall, A. G. Rudd, and C. D. Wolfe (2002). Cognitive impairment after stroke: clinical determinants and its associations with long-term stroke outcomes. *Journal of the American Geriatrics Society 50*(4), 700–706.

Rohwedder, S. and R. J. Willis (2010). Mental retirement. *Journal of Health Economics 24*, 119–138.

Salthouse, T. A. (2006). Mental exercise and mental aging : Evaluating the validity of the "use it or lose it" hypothesis. *Perspectives on Psychological Science 68*(1), 1–21.

Stock, J. H. and D. A. Wise (1990). Pensions, the option value of work, and retirement. *Econometrica 58*(5), 1151–1180.

Wooldridge, J. M. (2002). Measurement error in the dependent variable. *Econometric Analysis of Cross Section and Panel Data*, 71–74.

B Tables and Regression Output

Table 1: Descriptive Statistics, NPHS data

Variable	Mean, non-retired	Mean, retired
Age	59.75	65.91
Male	.55	.40
Female	.45	.60
Caucasian	0.924	0.947
Non-caucasian	0.076	0.053
Single household	0.046	0.068
Education, years	12.08	11.34
Health factors		
Stroke	0.007	0.020
Heart disease	0.065	0.101
High blood pressure	0.219	0.385
Cognitive function†	1.46	1.59

Workforce status	Mean
Retired‡	0.437
Reached age 61	0.60
Reached age 65	0.36

Notes: Data obtained from the National Population Health Survey, 1994-2008.

† Cognitive function here is measured as an index of '1' to '6', where '1' indicates no cognitive problems reported, and '6' indicates an inability to think or remember.

‡ Self-reported.

Table 2: POLS estimates, Retirement effects on Cognitive function

	Self-reported cognitive issues	
	(i)	(ii)
Retirement measure:	Self-reported	Imputed
Retired for 0-4 years	0.0278**	0.0347***
	(0.0124)	(0.0122)
Retired for 5-9 years	0.0274	0.0449**
	(0.0178)	(0.0181)
Retired for 10 years or more	0.0500*	0.0671**
	(0.0282)	(0.0261)
Age	-0.0400***	-0.0354***
	(0.0114)	(0.0112)
Age^2	0.000342***	0.000299***
	(0.0000897)	(0.0000885)
Heart disease	0.111***	0.110***
	(0.0194)	(0.0194)
Stroke	0.150***	0.148***
	(0.0481)	(0.0480)
Single household	0.0259	0.0265
	(0.0227)	(0.0227)
High blood pressure	0.0187*	0.0178
	(0.0109)	(0.0109)
Female	0.000169	-0.00243
	(0.00959)	(0.00965)
Not caucasian	0.0258	0.0269
	(0.0195)	(0.0195)
Education, $years^2$	-0.000337***	-0.000329***
	(0.0000535)	(0.0000536)
Constant	1.407***	1.284***
	(0.362)	(0.353)
Observations	8214	8214
R^2	0.024	0.024

Robust standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Note: Regression data obtained from the National Population Health Survey, 1994-2008.

Table 3: First-Stage IV-FE Estimates

	Retirement	
	(i)	(ii)
Measure:	Self-reported	Imputed
Incentives at age 61	0.136***	0.135***
	(0.0123)	(0.0127)
Incentives at age 65	0.181***	0.0961***
	(0.0120)	(0.0124)
Age	0.0972***	0.0326***
	(0.0105)	(0.0108)
Age^2	-0.000527***	-0.0000461***
	(0.0000829)	(0.0000853)
Heart disease	0.0511***	0.0505***
	(0.0179)	(0.0184)
Stroke	0.0796**	0.0630
	(0.0375)	(0.0386)
Single household	0.0541**	0.0290
	(0.0248)	(0.0255)
High blood pressure	0.0469***	0.0411***
	(0.0129)	(0.0133)
Constant	-3.796***	-1.860***
	(0.331)	(0.341)
R^2	0.477	0.441
Observations	8214	8214
Number of respondents	1120	1120

Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Regression data obtained from the National Population Health Survey, 1994-2008.

Test for joint-significance of age 61 and age 65 incentive variables returns:

Self-reported measure of retirement:

$Chi^2(2) = 171.09; Prob > Chi^2 = 0.0000$

Imputed measure of retirement:

$Chi^2(2) = 85.27; Prob > Chi^2 = 0.0000$

Table 4: IV-FE estimates, Retirement effects on Cognitive function

	Self-reported cognitive issues	
	(i)	(ii)
Retirement measure:	Self-reported	Imputed
Retired	0.154*	0.231***
	(0.0788)	(0.0689)
Age	-0.0838***	-0.0807***
	(0.0166)	(0.0163)
Age^2	0.000637***	0.000580***
	(0.000123)	(0.000131)
Heart disease	0.0539**	0.0500**
	(0.0252)	(0.0252)
Stroke	0.0102	0.0077
	(0.0743)	(0.0632)
Single household	-0.0205	-0.0196
	(0.0401)	(0.0261)
High blood pressure	0.00397	0.00182
	(0.0177)	(0.0172)
Constant	2.889***	2.878***
	(0.560)	(0.520)
Between R^2	0.0164	0.0120
Overall R^2	0.0067	0.0069
Observations	8214	8214
Number of respondents	1120	1120

Bootstrap Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Regression data obtained from the National Population Health Survey, 1994-2008. The standard errors were estimated using the VCE bootstrap option in STATA.

Table 5: IV-FE estimates, Retirement effects on Cognitive function

	Self-reported cognitive issues, non-imputed	
	(i)	(ii)
Retirement measure:	Self-reported	Imputed
Retired	0.137*	0.212***
	(0.0708)	(0.1)
Age	-0.0873***	-0.0849***
	(0.0171)	(0.0151)
Age^2	0.000672***	0.000622***
	(0.000133)	(0.000116)
Heart disease	0.0559*	0.0527**
	(0.0302)	(0.0254)
Stroke	0.00364	0.000529
	(0.0504)	(0.0678)
Single household	-0.0178	-0.0175
	(0.0284)	(0.0299)
High blood pressure	0.00349	0.00149
	(0.0163)	(0.0167)
Constant	2.981***	2.987***
	(0.561)	(0.520)
Between R^2	0.0139	0.0175
Overall R^2	0.0079	0.0072
Observations	8100	8100
Number of respondents	1119	1119

Bootstrap Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Regression data obtained from the National Population Health Survey, 1994-2008. The standard errors were estimated using the VCE bootstrap option in STATA.

Table 6: FE estimates, truncated sample, Retirement effects on Cognitive function

	Self-reported cognitive issues	
	(i)	(ii)
Dependent variable:	Imputed	Non-imputed
Retired	0.0724***	0.0713***
	(0.0708)	(0.1)
Age	-0.0558***	-0.0590***
	(0.0144)	(0.0110)
Age^2	0.000496***	0.000523***
	(0.000133)	(0.0000916)
Heart disease	0.142**	0.146**
	(0.0694)	(0.0656)
Stroke	-0.0231	-0.0262
	(0.149)	(0.117)
Single household	-0.0129	-0.00694
	(0.0279)	(0.0273)
High blood pressure	-0.0232*	-0.0239
	(0.0138)	(0.0160)
Constant	1.575***	1.667***
	(0.425)	(0.333)
R^2	0.062	0.064
Observations	3808	3757
Number of respondents	524	523

Bootstrap Standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Regression data obtained from the National Population Health Survey, 1994-2008. The standard errors were estimated using the VCE bootstrap option in STATA.

Table 7: IV-RE Probit and IV-RE Logit model estimates: Retirement effects on Cognitive Function

	Self-reported cognitive issues	
	(i)	(ii)
	IV-RE Probit	IV-RE Logit
Retired	0.264***	0.296***
	(0.0964)	(0.107)
Age	-0.587***	-1.335***
	(0.140)	(0.356)
Age^2	0.00373***	0.00830***
	(0.000752)	(0.00193)
Heart disease	0.235***	0.368**
	(0.0900)	(0.164)
Stroke	0.0802	0.0875
	(0.186)	(0.324)
Single household	-0.125	-0.285
	(0.120)	(0.216)
High blood pressure	-0.0389	-0.103
	(0.0717)	(0.134)
Constant	21.04***	49.13***
	(5.924)	(14.78)
$\ln(\sigma_u^2)$	0.0310	1.148***
	(0.0785)	(0.0813)
Wald $\chi^2(7)$	94.86	95.64
prob > χ^2	0.0000	0.0000
Observations	8214	8214
Number of respondents	1120	1120

Unadjusted† standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Regression data obtained from the National Population Health Survey, 1994-2008. The imputed measure of retirement is used in instrumentation.

† The standard errors employed here are unreliable due to failing to take into account the estimation in the first stage; i.e. $\hat{X}_{it}$ is estimated.

Table 8: IV-RE Probit and IV-RE Logit average marginal effects

	Self-reported cognitive issues	
	(i)	(ii)
	IV-RE Probit	IV-RE Logit
Retired	0.0613***	0.0364***
	(0.0225)	(0.0132)
Age	-0.136***	-0.164***
	(0.0329)	(0.0443)
Age^2	0.000865***	0.00102***
	(0.000176)	(0.000241)
Heart disease	0.0544***	0.0451**
	(0.0209)	(0.0201)
Stroke	0.0186	0.0107
	(0.0433)	(0.0398)
Single household	-0.0291	-0.0350
	(0.0279)	(0.0266)
High blood pressure	-0.00903	-0.0126
	(0.0167)	(0.0165)

Unadjusted† standard errors in parentheses

*** p < 0.01, ** p < 0.05, * p < 0.1

Notes: Regression data obtained from the National Population Health Survey, 1994-2008. The imputed measure of retirement is used in instrumentation.

† The standard errors employed here are unreliable due to failing to take into account the estimation in the first stage; i.e. $\hat{X}_{it}$ is estimated.

Table 9: IV-FE Logit estimates, Retirement effects on Cognition

	Self-reported cognitive issues
Retired	0.272***
	(0.0990)
Age	-0.893***
	(0.175)
Age^2	0.00488***
	(0.000780)
Heart disease	0.360**
	(0.161)
Stroke	-0.0867
	(0.311)
Single household	-0.372
	(0.241)
High blood pressure	0.00258
	(0.131)
LR $\chi^2(7)$	73.66
prob > χ^2	0.0000
Observations	4896
Number of respondents	661

Unadjusted† standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Regression data obtained from the National Population Health Survey, 1994-2008. The imputed measure of retirement is used in instrumentation.

† The standard errors employed here are not correct due to failing to take into account the estimation in the first stage; i.e. $\hat{X}_{it}$ is pre-estimated.

Table 10: IV-FE Logit odds ratios

	Self-reported cognitive issues
Retired	1.312***
	(0.130)
Age	0.410***
	(0.0717)
Age^2	1.005***
	(0.000783)
Heart disease	1.43**
	(0.231)
Stroke	0.917
	(0.285)
Single household	0.689
	(0.166)
High blood pressure	1.00258
	(0.131)

Unadjusted† standard errors in parentheses
*** p < 0.01, ** p < 0.05, * p < 0.1

Notes: Regression data obtained from the National Population Health Survey, 1994-2008. The imputed measure of retirement is used in instrumentation.

† The standard errors employed here are not correct due to failing to take into account the estimation in the first stage; i.e. $\hat{X}_{it}$ is pre-estimated.