I Z A Institute
of Labor Economics
Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 12073

Ageing and Skills: The Case of Literacy Skills

Garry F. Barrett
W. Craig Riddell

JANUARY 2019

I Z A Institute
of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 12073

Ageing and Skills: The Case of Literacy Skills

Garry F. Barrett
University of Sydney and IZA

W. Craig Riddell
University of British Columbia and IZA

JANUARY 2019

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Ageing and Skills: The Case of Literacy Skills

The relationship between ageing and skills is of growing policy significance due to population ageing, the changing nature of work and the importance of literacy for social and economic well-being. This article examines the relationship between age and literacy skills in a sample of OECD countries using three internationally comparable surveys. By pooling the survey data across time we can separate birth cohort and ageing effects. In doing so we find literacy skills decline with age and that, in most of our sample countries, successive birth cohorts tend to have poorer literacy outcomes. Therefore, once we control for cohort effects the rate at which literacy proficiency falls with age is much more pronounced than that which is apparent based on the cross-sectional relationship between age and literacy skills at a point in time. Further, in studying the literacy-age relationship across the skill distribution in Canada we find a more pronounced decline in literacy skills with age at lower percentiles, which suggests that higher initial literacy moderates the influence of cognitive ageing.

JEL Classification: I20, J14, J24

Keywords: human capital, ageing, cognitive skills, literacy, cohort effects

Corresponding author:
W. Craig Riddell
Vancouver School of Economics
Faculty of Arts
University of British Columbia
6000 Iona Drive
Vancouver, BC, V6T 1L4
Canada

E-mail: craig.riddell@ubc.ca

1. Introduction

The relationship between ageing and skills is of growing importance because of several inter-related developments. One is the ageing of the population in many developed countries due to large baby boom cohorts that are now at or nearing retirement age and followed by much smaller birth cohorts. Another is increased longevity and related factors – such as the declining incidence of defined benefit pension plans, the abolition of mandatory retirement and the extension of 'normal retirement age' in public pension plans – that are resulting in more individuals wanting to continue working beyond what were traditionally thought of as retirement age. The extent to which skills depreciate at older ages is thus relevant to employers as well as to workers who might want to prolong their working lives. In addition, if workplace-relevant skills decline sharply with age these developments could have negative implications for the aggregate productivity of the economy and thus for overall standards of living.

In addition, technological change and globalization of economic activity that are changing the nature of work in profound ways, several of which appear likely to require workers to maintain skills and/or acquire new skills throughout their working lives. The notion of stable career jobs is becoming less relevant and being replaced by the likelihood that workers will have several careers. The extent to which existing skills are transferable to new work settings as well as the extent to which skills atrophy over time are important for understanding the magnitudes of any adverse consequences associated with the changing nature of work.

The 'death of distance' and the associated globalization of economic activity also have profound consequences for the regional distribution of economic activities. As manufacturing and processing activities increasingly shift to low wage countries, high wage advanced countries need to focus more on high value-added knowledge-intensive activities. Doing so requires a highly skilled workforce, as well as one that can adapt rapidly to economic and technological change.

Technological change and globalization also result in winners and losers. Recent evidence indicates that although many job losers become re-employed relatively quickly at wages similar to those earned in the pre-displacement job, an important subset of displaced

workers suffer large and persistent losses from permanent job loss (see, e.g., Riddell (2012) for a survey of this evidence). These large losses affect not only the individuals themselves but also other family members including their children, thus having inter-generational impacts. Whether there are types of skills that can be acquired early in life – or acquired and/or maintained during the pre-displacement employment period – and that would reduce the costs of permanent job loss is thus an important policy issue. Too frequently the policy response is a 'repair shop' approach that attempts to 'pick up the pieces' after the adverse employment shock has occurred.

Key objectives of this paper are to examine the relationship between age and literacy skills in numerous developed countries and to discuss the implications of this evidence. Our empirical analysis utilizes three internationally comparable surveys of the literacy skills of the adult population: the International Adult Literacy Survey (IALS), carried out in over 20 countries during the period 1994-1998, the Adult Literacy and Life Skills Survey (ALL) carried out approximately a decade later, and the recent Survey of Adult Skills, a product of the OECD Programme for the International Assessment of Adult Competencies (PIAAC). The advantages of these remarkable surveys for our purposes, as well as their limitations, are discussed below.

We focus on literacy skills in part because of the availability of high-quality cross-country data but principally because of the role these skills play in human well-being. Amartya Sen (1999) argues that we should aim to achieve societies in which all members are capable of pursuing their goals. Doing so requires at least some minimal level of resources as well as what Sen refers to as 'functionings.' Literacy is one of the most important such functionings. Without adequate literacy skills individuals cannot meaningfully participate in social and political discourse: they become less than equal participants in society without the tools needed to pursue their goals. Literacy skills also have important consequences for economic well-being. Individuals with greater literacy enjoy better employment opportunities and receive higher earnings (Green and Riddell, 2003; Hanushek et al 2015). From the point of view of economic performance, a more highly educated and literate workforce may be more able to adjust to change and to adapt new technologies (Riddell and Song, 2017). Thus, improving literacy skills

may have benefits not only for individuals but also may have spillover effects that benefit the economy as a whole.

The rest of the paper is organized as follows. Because the term "skills" is used in a variety of contexts the next section briefly discusses various types of skills and their measurement. Section three briefly reviews previous literature on how skills evolve with age. The fourth section describes our data and section five presents and discusses our empirical results. The final section concludes.

2. Meaning and Measurement of Skills

We begin with economists' general notion of skills: anything that enhances an individual's productivity in carrying out tasks. Such a general definition includes several distinct types of skills: cognitive skills such as literacy, numeracy and problem-solving; personality traits (also referred to as non-cognitive skills or 'soft skills') such as perseverance, determination, ability to get along with others); and fluid, crystallized and general intelligence. Each of these broad groups can be further categorized; for example, Desjardins and Warnke (2012) distinguish between 'basic cognitive skills' and 'cognitive foundation skills.'

Fluid intelligence (similar to the concept of cognitive mechanics) refers to the ability to learn or understand things independent of prior knowledge. Examples include processing speed, attention capacity, spatial ability, reasoning, and working memory capacity. These types of skills are believed to be primarily genetically and biologically determined (Baltes, 1993; Toga and Thompson, 2005). Crystallized intelligence (similar to the concept of cognitive pragmatics) refers to cognitive functioning such as knowledge, abilities and wisdom that are acquired or learned (Baltes, 1993). These are believed to be primarily socially and culturally determined. Literacy skills are likely to reflect an individual's fluid and crystallized intelligence. For example, Green and Riddell (2003, 2013) find that the primary driver of literacy skills is formal educational attainment which reflects an individual's fluid and crystallized intelligence.
In the workplace, skills make employees more valuable to the employer, increasing employer demand for such workers and, in a competitive labour market, will result in higher earnings. Skills such as literacy and numeracy also very important for many other reasons including social

engagement, participation in civic affairs, and making good life course decisions (e.g. financial literacy).

There are several ways to measure skills:

i) Input-based – e.g. amount of formal education, work experience and extent of learning on-the-job

ii) Assessment-based – e.g. SAT, ACT, KWW, IALS-type literacy and numeracy skills

iii) Task or job content based – these often use Dictionary of Occupational Titles (DOT) measures of the task and skill content of jobs

This paper we will focus on assessment-based measures of skills, specifically literacy skills.

3. Evidence on Relationship between Ageing and Skills

There is a substantial literature on this topic, especially from psychology and the cognitive sciences. Desjardins and Warnke (2012) – referred to as DW (2102) subsequently – provide a comprehensive survey and references to this burgeoning literature.

A common view is that several measures of fluid intelligence rise sharply during childhood, peak during teen-age years, and then steadily decline with age (Cattell, 1987). For example, measures of speed, reasoning, memory and spatial ability display a declining pattern beginning at age 20 or earlier (Verhaeghen and Salthouse, 1997; Schaie, 1994, 2005), Salthouse, 2004). Crystallized intelligence, in contrast, rises with age before leveling off around age 50. DW (2012, Figure 2) illustrates the general pattern. Measures of vocabulary and verbal ability are examples of this pattern (Salthouse, 2004; Schaie, 2005). General intelligence – which reflects both fluid and crystallized intelligence – is believed to rise during childhood and teenage years and remain relatively stable throughout adulthood (Cattell, 1987).

A central point emphasized in the economics literature on human capital is that the pattern of skill observed over the life cycle responds to the incentives to acquire and maintain skills. Early models of the optimal pattern of skill acquisition over the life cycle (e.g. Ben-Porath, 1967) predict that skill acquisition begins with a period of full-time investment (formal schooling), followed by a period of part-time investment (work combined with on-the-job training and learning by doing), followed by a period of replacement investment to offset skill

depreciation, and finally by a period in which skills are allowed to depreciate as retirement approaches. The fundamental underlying reason for this pattern is that human capital investments yield a financial return only over extended periods of time. Thus, full-time investment in schooling is best done early in the life cycle and late in the life cycle even replacing existing skills no longer yields a sufficiently high return to justify the investment. This theoretical argument provides an explanation for the empirical regularity observed in many countries and time periods of a concave life-cycle earnings profile, with earnings rising sharply during early adulthood after entry into the workforce, rising at progressively lower rates in subsequent years before peaking at ages in the 50s or early 60s and then declining.

While the Ben-Porath framework provides a useful starting point for understanding the incentives to invest in skills over time, it applies only under simplified conditions: individuals who plan to be in the labour force on a full-time basis until retirement, acquiring a purely general skill that is transferable across employers, and in an environment where the demand for that skill is stable over the worker's lifetime. Altering these assumptions – for example, to allow for individuals who leave the labour force for a certain period, such as for child raising, or for a world in which there are numerous types of skills, the demand for which is subject to unpredictable change over time – would alter the predicted optimal pattern of skill acquisition. Nonetheless, the key point that the pattern of skill acquisition and maintenance over the life cycle is likely to respond to the incentives created by the economic environment still holds. Thus, while the initial stock of skills may be principally genetically and biologically determined, and decline steadily with age beginning in the late teenage years or early 20s, other skills and abilities may improve with age, in part because of the incentive to continue to invest in acquiring new skills as well as maintaining existing skills. This is the case not only because of any incentives arising for maintaining or increasing one's earning power in the labour market but also because of the incentives to continue to enjoy life and participate actively as one ages – 'healthy ageing'.

Measures of literacy skills such as those obtained from IALS and subsequent surveys reflect both fluid and crystallized intelligence, as well as the incentives to acquire and maintain these

skills. A central objective of this paper is to summarize new evidence about the relationship between these skills and age.

4. Data

Most broad-based assessments of skills are carried out among children, youths and young adults during the period of formal schooling or shortly thereafter. Our data come from the IALS, ALL and PIAAC surveys that provide, for the first time, measures of the literacy (and numeracy) skills of the adult population (those age 16 to 65).[1] These remarkable surveys combine methods of educational testing with household survey techniques to provide measures of the skills that are representative of the adult population. Furthermore, IALS, ALL and PIAAC were designed to provide skill assessments that are comparable across countries and language groups. The IALS and ALL data on 'prose literacy' and 'document literacy' have been re-scaled to be comparable to the PIAAC single measure of literacy that combines prose and document literacy, so the measures are thus also comparable over time.

A key feature of IALS, ALL and PIAAC is that they combine basic knowledge and skills such as vocabulary, language proficiency and comprehension with the ability to apply these basic skills in circumstances that arise in everyday life – at work, at home and in the community. The level of difficulty ranges from easy – for example, identifying recommended dosages from instructions on an aspirin bottle – to more complex – such as using an announcement from a personnel department to answer questions that use different phrasing from that in the text – to difficult – such as reading a complex document from a consumer magazine and determining the average advertised price for a product with the highest rating in a specific dimension. Questions may also require respondents to locate and use information in various forms, whether from an order form, a bus schedule or a restaurant menu.

The surveys also provide information on a rich set of demographic and personal characteristics, allowing us to use multiple regression methods to control for influences on literacy in addition to age. These include not only standard demographics such as gender, age, educational attainment but also immigrant status, country of origin, aboriginal status, mother's

[1] For some countries the IALS and ALL surveys covered those 16 and over, but the PIAAC sample is restricted to those of 'working force age' so we are limited to the range 16 to 65.

and father's education, and mother's and father's immigrant status. Thus, for example, we can compare the literacy skills of 45 year-old men with a high school diploma to those of 35 year-old men with a high school diploma to see how the literacy skills of male high school graduates evolve between age 35 and 45. The main limitation of the three surveys is that each is cross-sectional in nature. Ideally, we would prefer longitudinal data so that we could see how the skills of individuals evolve over time as they age.[2] Unfortunately, to our knowledge there are no longitudinal surveys of the literacy skills of the adult population, and there are certainly none that are comparable across countries and language groups.[3]

The key problem with using cross-sectional surveys to study the effects of age is that doing so confounds age effects with what are often referred to as 'cohort effects.' The literacy skills of 45 year-old male high school graduates may differ from those of their 35 year-old counterparts at a point in time not only because they are 10 years older but also because they were born 10 years earlier, and may have experienced differences in the nature and quality of school systems, and other differences such as parental norms for fostering literacy skills of their children, peers and work experience. For example, if the quality of elementary and secondary schooling improved over time we would expect the literacy of 35 year-olds to be greater than that of 45 year-olds when they were 35 years of age, and vice versa if school quality deteriorated.

Although longitudinal data is preferred, the problem of confounding age and birth cohort effects can be addressed using a series of cross-sectional surveys provided that each is representative of the population of interest and the population itself doesn't change over time. In such circumstances, 26-35 year-olds surveyed in the 1994 IALS, 35-44 year-olds in the 2003 ALL and 44-53 year-olds in the 2012 PIAAC are all representative samples of the 1959-68 birth cohort. All three samples represent the same cohort; thus, observed skill differences are attributable to ageing, not cohort effects. Given their suitability for these 'quasi-longitudinal'

[2] Several longitudinal skills studies such as the Seattle Longitudinal Study (Schaie, 1994) have been carried out; however, these typically focus on specific groups with possibly characteristics that are specific to that group. Although highly informative it is difficult to generalize from these studies to the overall adult population.

[3] The German Socio-Economic Panel, Canadian Longitudinal and International Survey of Adults and the Household, Income and Labour Dynamics in Australia Survey have recently started providing longitudinal data on literacy and numeracy skills. However, it will be many years before these data sources will be useful for studying the relationship between literacy skills and age.

methods and their other advantages, the IALS, ALL and PIAAC surveys provide the best available evidence on the relationship between age and literacy for the overall adult population.

5. Empirical Analysis

We present evidence on the relationship between literacy skills and age for four countries that participated in all three surveys (Canada, Netherlands, Norway and U.S.A.) and four countries that participated in IALS and PIAAC (Belgium, Ireland, Finland and Sweden). The analysis builds on our previous research – see Barrett and Riddell (2016) for details of the specification and estimation.[4]

We restrict the data from each survey in several important ways. First, we drop immigrants from the sample. Focusing on the native born is essential for ensuring that the underlying population is unchanged over time. Native born birth cohorts change only because of deaths and emigration, neither of which is substantial enough for the age range 16-65 to affect the analysis. Dropping immigrants has two further advantages. The skill assessments are carried out in the official language(s) of each country (e.g. English and French in the case of Canada) so the skills of many immigrants are not assessed in their native language. Consequently, the assessments confound language proficiency in the language of the new country with literacy skills in their native language. Also, focusing on those educated in the country of interest allow us to make policy inferences about the quality of the country's education system. For similar reasons we also drop aboriginals from samples in countries in which aboriginals are separately identified.[5]

We also follow Green and Riddell (2013) by restricting the analysis to those over age 25 in order to focus on those who have completed formal schooling. Several studies conclude that the primary determinant of literacy is formal education; thus, it is crucial to control for education when examining the relationship between literacy and age. An important limitation of studies (e.g. Willms and Murray, 2007) that report 'ageing effects' between ages 16 and 25 is

[4] Barrett and Riddell (2016) use the log of literacy score as the dependent variable. For presentation purposes, in this paper the predicted effects on the literacy score level are shown and discussed.

[5] Many aboriginals speak languages different from the country's official language(s). Also, in some countries (e.g. Canada) only aboriginals living off reserves were surveyed and there are significant movements on and off reserves, resulting in changes in the underlying population.

that most respondents in this age range are participating in secondary or post-secondary education. The skill gain between age 16 and 25 is thus principally attributable to the additional education received rather than to an ageing effect. An illustration of this problem is provided by Cascio, Clark and Gordon (2008) who use IALS data and show that there is a large variation across countries in the literacy skill gain between ages 16-17 and 26-30 and this skill gain is highly correlated with the extent of participation in post-secondary education across countries.

In order to not restrict the shape of the estimated literacy-age relationship we employ a flexible (non-parametric) specification of the age effect based on dummy variables for each age category.[6] Unfortunately, data restrictions limit the analysis to 10-year age categories (26-35, 36-45, 46-55, 56-65) – narrower categories would be preferred. The three surveys do, however, provide a rich set of covariates to control for other influences on skills: gender, educational attainment, mother's and father's education, and mother's and father's immigrant status.

For each country we show three versions of the estimated relationship between literacy skills and age after controlling for other influences. The first ('model 1' in the figures) doesn't control for cohort effects or parental education and immigrant status (variables often not available in surveys). This figure shows the estimated cross-sectional relationship between literacy and age controlling for gender and education. Model 2 adds controls for cohort effects and model 3 adds controls for parent's education and immigration status. All estimated models pool data from IALS, ALL and PIAAC (or IALS and PIAAC for countries not participating in ALL).

Figure 1 plots the relationship between literacy skills and age for Canada, which had the largest sample size in all three surveys. Model 1 includes controls for gender and a quadratic in years of schooling, along with age. The regression estimates show a progressive decline in average literacy skill levels with age. Given the sample was chosen to focus on the post-schooling relationship between literacy proficiency and age, the successive decline of literacy with age is consistent with Green and Riddell's (2013) findings on both the importance of schooling in generating gains in literacy, and the general deterioration of those skills post-school. The initial decline in literacy over age 25-34 to 35-44 is slight, then accelerates over older ages to age 55-64. There is an overall decline in average literacy levels of 5.5 percent

[6] In contrast, Willms and Murray (2007), among others, employ a quadratic in age which may be overly restrictive.

between ages 25-34 and 55-64. By pooling the three surveys we are able to include controls for birth cohort, which corresponds to model 2. As is evident from Figure 1, controlling for mean cohort differences in literacy levels leads to a steeper decline in literacy with age. For model 2, average literacy levels decline by 10 percent between ages 25-34 and 55-64, implying a much stronger ageing effect. This finding highlights the importance of controlling for cohort differences when assessing the impact of ageing. The estimates for model 2 indicate that more recent cohorts tend to have lower literacy levels. Consequently, the higher literacy levels of earlier cohorts masked the extent of the deterioration in literacy skills with age found with model 1.

The final literacy –age profile shown in Figure 1 is for model 3 that includes controls for mother's and father's education, and mother's and father's immigrant status. Controlling for these additional influences leads to a slightly steeper literacy-age gradient. However, the difference in the literacy - age relationship between models 2 and 3 is very small, indicating that the additional control variables were not strongly correlated with age. Overall, the results for Canada show a significant decline in mean literacy levels with age, while highlighting the importance of controlling for average cohort differences when assessing the effects of ageing on literacy.

Using the same three models, Figure 2 shows estimated literacy skills – age relationships for Norway. As found for Canada, literacy skills successively decline with age post-schooling, but the decline is much steeper in Norway. The estimated decline in literacy skills due to ageing is also found to be much greater once differences in average cohort literacy levels are controlled for. Models 2 and 3, which include cohort controls, show a 20 percent decline in average literacy levels between 25-34 and 55-64 due to ageing, approximately double that experienced in Canada. There are also important differences in average literacy level by cohort – larger than those observed in Canada. The cohort differences tend to mask the full effects of ageing on literacy when viewing the cross-sectional pattern of literacy level with age.

Estimation was also carried out for the Netherlands, Belgium, Ireland, Finland, Sweden and the U.S.A. The estimated literacy skill – age relationships based on model 3, with the full set of controls, for these countries – along with Canada and Norway for comparison – are shown in

Figure 3. Several features are evident from these profiles. One is the general pattern of declining average literacy levels with age. Second, the European countries examined can be divided into two broad groups. The first group (Netherlands, Finland, Belgium) exhibit rates of decline in literacy with age comparable to that found for Canada and U.S.A. The second group (Sweden, Norway, Ireland) show a more substantial decline in literacy levels with age: among these three countries mean literacy levels decline on average by 20 percent between ages 25-34 and 55-64, approximately double that found for the other countries. These countries also tend to have larger differences in mean levels of literacy across cohorts. An interesting area of future research is to investigate the factors contributing to the different literacy – age profiles across countries, along with cohort differences, and the possible role played by national education and public pension systems.

Although our principal focus is on the relationship between skills and age, after controlling for cohort effects, the patterns of the cohort effects also warrant mention.[7] In three of these countries (Belgium, Finland and Netherlands) the estimated cohort effects are negative in sign, small in magnitude (2% to 4%) and stable across birth cohorts. This pattern implies that earlier birth cohorts had literacy skills that are 2% to 4% lower at age 26-35 than the most recent birth cohort (those aged 26 to 35 in the PIAAC skills assessment), controlling for other influences on literacy skills. In the other five countries the estimated cohort effects are positive in sign, indicating that more recent cohorts have lower literacy skills at age 26-35 than did earlier birth cohorts, controlling for other influences on skills. In these countries the estimated cohort effects are largest for the earliest birth cohorts and decline in size over time, a pattern that implies that successive birth cohorts have lower literacy skills at age 26-35 than preceding cohorts. There is also substantial variation across countries in the size of these effects. The smallest cohort effects are those for Canada and the U.S., where literacy levels are approximately 8% higher for the earliest birth cohorts, declining to 2% for the most recent birth cohort preceding the 26 –35 year-olds in PIAAC 2012. At the other extreme, Norway and Ireland have estimated cohort effects that are about 16% higher for the earliest birth cohorts, declining

[7] Estimated cohort effects are reported in Tables A3 and A4 in Barrett and Riddell (2016).

to 4% (Norway) and 8% (Ireland) for the cohort preceding the PIAAC cohort. Sweden is an intermediate case with cohort effects that decline over time from 12% to 3%.

Cohort effects that are negative in sign imply that the 'true' impact of ageing on skills is flatter (less negatively sloped) than the cross-sectional relationship, whereas the reverse holds for cohort effects that are positive in sign. The magnitudes of the cohort effects alter the difference between the observed cross-sectional relationship between age and skills and the actual underlying relationship between skills and age. For example, in Figure 1 for Canada the impact of age on skills controlling for cohort effects is shown by models 2 and 3 whereas the cross-sectional relationship (that reflects both cohort and ageing effects) is that associated with model 1. The line that shows the impact of ageing on skills is steeper than the cross-sectional relationship and the vertical difference between the two lines is about 2% for the youngest birth cohort (35-44 year-olds) prior to the most recent cohort and about 8% for the oldest (55-64 year-olds) cohort. In contrast, in Figure 3 for Norway the difference between the cross-sectional and true ageing relationships is much greater, reflecting the larger estimated cohort effects for Norway that range from 4% to 16%.

The international comparison of literacy skill – age profiles thus reveals important differences across countries – differences in both the relationship between ageing and skills at a point in time and in the evolution of literacy skills across birth cohorts over time. Understanding the factors that may influence these differences is an important challenge for future research. Because previous research concludes that formal education is the dominant factor influencing literacy skills – and because the estimated relationships control for the quantity of education received – changes in the quality of schooling over time represent one potential explanation for the differences across countries in the skills of successive birth cohorts. Among the countries examined here, this explanation would suggest that school quality has declined in most countries, although there are some exceptions (Belgium, Finland and Netherlands) in which modest improvements in school quality may have taken place. Of course, there are numerous alternative explanations for the changes in literacy skills among young adults across different birth cohorts – such as technological changes that have altered the nature and role of reading and writing in communication and everyday activities as well as

parental attitudes and involvement in reading and writing activities of their children. It is also possible that schooling systems have become less productive in enhancing literacy skills but higher quality for non-cognitive skills or other cognitive skills.

There is a large literature examining the effect of public pension systems on individual and family incentives to retire. Retirement plans in turn have implications for decisions concerning the accumulation of skills early in life, and on maintaining skills later in life. In general, the public pension systems of European countries provide stronger inducements to retire early compared to North America. The incentives to maintain literacy skills may also be less strong in the European countries, due to the lower economic return to investing in the skill maintenance activities.[8] An interesting question for future research is whether these cross-country differences in retirement incentives and patterns contribute to the more rapid decline in literacy skills with age in Sweden, Norway and Ireland compared to Canada and the U.S.A. Equally important is understanding the differences found across the European countries in our study.

There is a developing literature which assesses whether retirement itself exacerbates cognitive decline. Important early contributions to this line of inquiry by economists include Rohwedder and Willis (2010) and Bonsang, Adam and Perelman (2012). As noted by Rohwedder and Willis (2010: 119-122), there is a widely observed positive relationship between employment and performance on cognitive assessments at older ages. However, as retirement is often a matter of individual choice, the direction of any causal relationship is not clear. For example, an individual who experiences much greater cognitive decline may retire earlier from cognitively demanding work than their peers. Similarly, those who retire early because of illness or disability may also experience cognitive decline due to deteriorating health. This pattern of selection into retirement generates a positive correlation between retirement and cognitive decline without there being a causal effect of retirement on skills per se.

[8] In related research Jappelli (2010) uses an international survey to assess international differences in economic literacy and finds that countries with more generous social security systems tend to have lower literacy levels. Japelli (2010) attributes this to incentives for acquiring economic literacy skills.

However, the human capital model does suggest causal channels from retirement to cognition. One mechanism is the notion that cognition is a skill whereby you either "use-it-or-lose-it". According to this perspective cognitive skills can be maintained through activities that provide physical and mental exercise to cognitive functioning. Relatedly, cognitively demanding and intellectually stimulating workplaces provide a suitable environment for maintaining cognitive skills. Another causal mechanism operates through the incentives for investment in skill maintenance activities. If an individual is planning on retiring an at early age, they may choose to reduce their investment in skill maintenance (given that investing in skill maintenance is costly) even while in employment. The more limited horizon over which to receive the returns from a given investment implies the individual will invest less – and decrease their involvement in cognitive maintenance – at a given age including while employed. In light of retirement being a matter of individual choice, recent research uses statistical techniques that can isolate potential causal effects of retirement. For example, instrumental variable methods are based on identifying a third variable, an 'instrumental variable,' that is strongly related to retirement choices but not directly related to cognition. A number of authors have used age of access to social security as a possible instrumental variable for retirement. The idea is that early and normal retirement ages defined by public pension schemes provide strong incentives for people to retire. The pension rules, in turn, are unrelated to individual levels (or cohort averages) of cognitive proficiency. Researchers have used cross-country variation in social security access age (Rohwedder and Willis 2010; Mazzonna and Peracchi 2012) and variation in access age within a country over time (Bonsang, Adam and Perelman 2012) to isolate variation in retirement that is independent of cognition. The general conclusion from this literature is that retirement does appear to have a negative causal effect on cognition, particularly over a longer horizon (10+ years), and the effects appear to differ by factors such as the level of formal education.

The results presented so far have considered how the mean level of literacy evolves with age across a range of countries. Although this is informative for the overall population, it may not accurately reflect the effects of ageing at different points in the skill distribution. To gain a fuller understanding of the effects across the distribution, we consider the case of

Canada which provides the largest sample of observations and hence has the potential to more reliably reflect patterns at different points in the distribution. We extend the methods from the standard regression estimator (which focussed on the conditional mean relationship between literacy and age) to the quantile regression estimator, and consider the relationship at the 10^{th}, 25^{th}, 50^{th} (or median), 75^{th} and 90^{th} percentiles. For brevity, we focus on model 3 specification with the full set of control variables, including the cohort controls. The estimated literacy – age profiles for the different quantiles are presented in Figure 4. The profile for each quantile has the same general shape as reported for the mean, with an initial gradual decline with age and a larger decrease at later ages. Further, the profiles are generally higher, and exhibit a slower rate of decline with age, at higher percentiles. This pattern implies that greater literacy proficiency (conditional on other factors) at age 25-34 is associated with a dampened ageing effect. In a sense, greater initial levels of literacy have a preventative or moderating influence on cognitive ageing and decline. The differences in the ageing effects across quantiles are quantitatively important. For example, as shown in Figure 4, starting at the same level of literacy at age 25-44, someone at the 75^{th} or 90^{th} percentile of the (conditional) skills distribution by age 55-64 will have expected literacy proficiency equal to that of someone at the 10^{th} or 25^{th} percentile at age 45-54. Over ages 45-54 to 55-64, someone at the 10^{th} or 25^{th} percentile of the distribution may expect their proficiency to decline by a further 4-5 percent. Therefore, the quantile regression patterns reveal importance differences in the pattern of literacy skill deterioration and ageing across the skill distribution.

6. Conclusions

The IALS, ALL and PIAAC surveys are unique in providing measures of basic literacy skills for representative samples of the adult population. We combine these data to investigate the relationship between literacy skills and ageing in eight participating countries. Pooling the data across different points in time allows us to separately identify birth cohort and ageing effects. By doing so we find literacy skills decline with age beginning in the mid-20s when most individuals have completed formal schooling. We also find that in many, but not all, of the countries examined in our study, successive birth cohorts tend to have poorer literacy

outcomes. The slight negative relationship between literacy skills and age found using cross-sectional data in the majority of countries results from offsetting age and cohort effects. Once we control for cohort effects, the rate at which literacy proficiency falls with age is much more pronounced. That is, the cross-sectional pattern of literacy and age often understates the extent to which literacy declines with age.

The rate at which literacy proficiency declines with age varies considerably across our sample of OECD countries. We find that countries fall into two broad groups. Literacy falls moderately with age in Canada, U.S.A., Netherlands, Finland and Belgium. For example, among this group literacy skills decline by approximately 10 percent from age 25-34 to 55-64, after controlling for other influences on skills. In contrast, Ireland, Sweden and Norway exhibit much more substantial declines in literacy proficiency with age, with literacy skills falling on average by 20 percent over the same age range.

In addition, differences in the literacy – age profile across the literacy skill distribution in Canada were examined. Important differences were found, with a more pronounced decline in literacy skills with age evident at lower percentiles of the skill distribution. This finding suggests that higher initial literacy proficiency moderates the influence of cognitive ageing.

Our findings raise several questions to be pursued in future research. One major issue is understanding the underlying factors that result in much more rapid declines in literacy skills in some European countries compared to Canada, the U.S. and other European countries. The recent literature linking retirement from the workforce to cognitive decline suggests that variations across countries in retirement age – often related to financial incentives to retire early – represent one potential explanation for these cross-country differences. Another important challenge is to identify the reasons why successive cohorts have lower literacy skills at age 25 in most, but not all, of the countries examined in this paper. Changes over time in school quality and/or shifts in the focus of schools away from the enhancement of literacy skills and toward improving other skills are a leading candidate, but certainly not the only plausible explanation.

References

Baltes, P.B. (1993). "The ageing mind: potential and limits," *Gerontologist*, vol. 33, no. 5, pp. 580-594.

Barrett, G.F. and W. C. Riddell (2016). "Ageing and Literacy Skills: Evidence from IALS, ALL and PIAAC" OECD Education Working Papers, No. 145. Paris: OECD Publishing. http://dx.doi.org/10.1787/5jlphd2twps1-en.

Ben-Porath, Y. (1967). "The Production of Human Capital and the Life Cycle of Earnings" *Journal of Political Economy* vol. 75, no. 4 Part 1, pp. 352-65.

Bonsang,E., S. Adam and S. Perelman (2012). "Does Retirement Affect Cognitive Functioning?" *Journal of Health Economics*, vol. 31, pp. 490-501.

Cattell, R.B. (1987) *Intelligence: Its Growth, Structure and Action*. New York: Elsevier.

Cascio, E., D. Clark and N. Gordon (2008). "Education and the age profile of literacy into adulthood," *Journal of Economic Perspectives*, vol. 22, no. 3, pp. 47-70.

Desjardins, R. and A. Warnke (2012). "Ageing and Skills: A Review and Analysis of Skill Gain and Skill Loss over the Lifespan and Over Time" *OECD Education Working Papers*, No. 72, OECD Publishing.

Ferrer, A., D. Green and W. C. Riddell (2006). "The effect of literacy on immigrant earnings," *Journal of Human Resources* vol. 41, pp. 380-410.

Green, D.A. and W. C. Riddell (2003). "Literacy and Earnings: An Investigation of the Interaction of Cognitive and Unobserved Skills in Earnings Generation," *Labour Economics* vol. 10, pp.165-84.

Green, D. A. and W. C. Riddell (2013). "Ageing and Literacy Skills: Evidence from Canada, Norway and the United States" *Labour Economics* vol. 22, pp. 16-29.

Hanushek, E.A., G. Schwerdt, S. Wiederhold and L. Woessmann (2015). "Returns to skills around the world: Evidence from PIAAC" *European Economic Review* vol. 73, pp. 103-130.

Jappelli, T. (2010) "Economic literacy: An international comparison," *Economic Journal* vol. 120 no. 548, pp. F429-F451.

Mazzonna, F. and F. Peracchi (2012). "Ageing, cognitive abilities and retirement," *European Economic Review*, vol. 56, pp. 691–710.

Organisation for Economic Cooperation and Development. "Are We Getting More or Less Skilled? Trends in Literacy and Numeracy Proficiency from IALS to ALL and PIAAC" EDU.WKP 2014.

Riddell, W. Craig (2012). "Unemployment Compensation and Adjustment Assistance for Displaced Workers: Policy Options for Canada" in *Making EI Work: Research from the Mowat Centre Employment Insurance Task Force* edited by Keith Banting and Jon Medow. Montreal and Kingston: McGill-Queen's University Press, pp. 361-389.

Riddell, W.C. and X. Song (2017). "The Role of Education in Technology Use and Adoption: Evidence from the Canadian Workplace and Employee Survey" *Industrial and Labor Relations Review* vol. 70, no. 5, pp. 1219-1253.

Rohwedder, S. and R. Willis (2010). "Mental Retirement" *Journal of Economic Perspectives*, vol. 24, no. 1, pp. 1-20.

Salthouse, T. (2004). "What and when of cognitive ageing" *Current Directions in Psychological Science* vol. 13, no. 4, pp. 140-44.

Shaie, K.W. (1994). "The course of adult intellectual development" *American Psychologist*, vol. 49, no. 4, pp. 304-13.

Schaie, K.W. (2005). *Developmental Influences on Adult Intelligence: The Seattle Longitudinal Study*. Oxford: Oxford University Press.

Sen, A. (1999). *Development as Freedom*. New York: Anchor Books.

Toga, A.W., & Thompson, P.M. (2005). "Genetics of brain structure and intelligence,' *Annual Review of Neuroscience*, vol. 28, pp. 1-23.

Verhaeghen, P. and T.A. Salthouse. (1997). "Meta-analyses of age-cognition relations in adulthood: Estimates of linear and non-linear age effects and structural models" *Psychological Bulletin* vol. 122, no. 3, pp. 231-49.

Willms, J.D. and S. Murray (2007). "Gaining and Losing Literacy Skills Over the Lifecourse" Ottawa: Statistics Canada, Catalogue no. 89-552-MIE – No. 16.

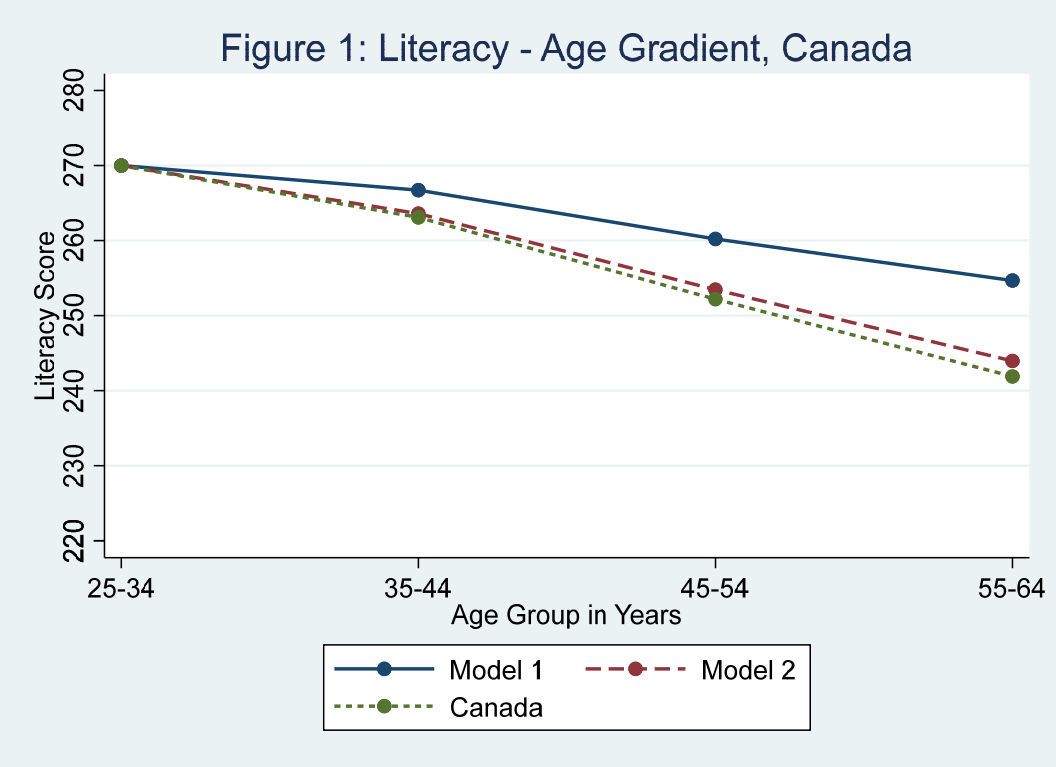
Figure 1: Literacy - Age Gradient, Canada
Literacy Score
220
230
240
250
260
270
280
25-34
35-44
45-54
55-64
Age Group in Years
Model 1
Model 2
Canada

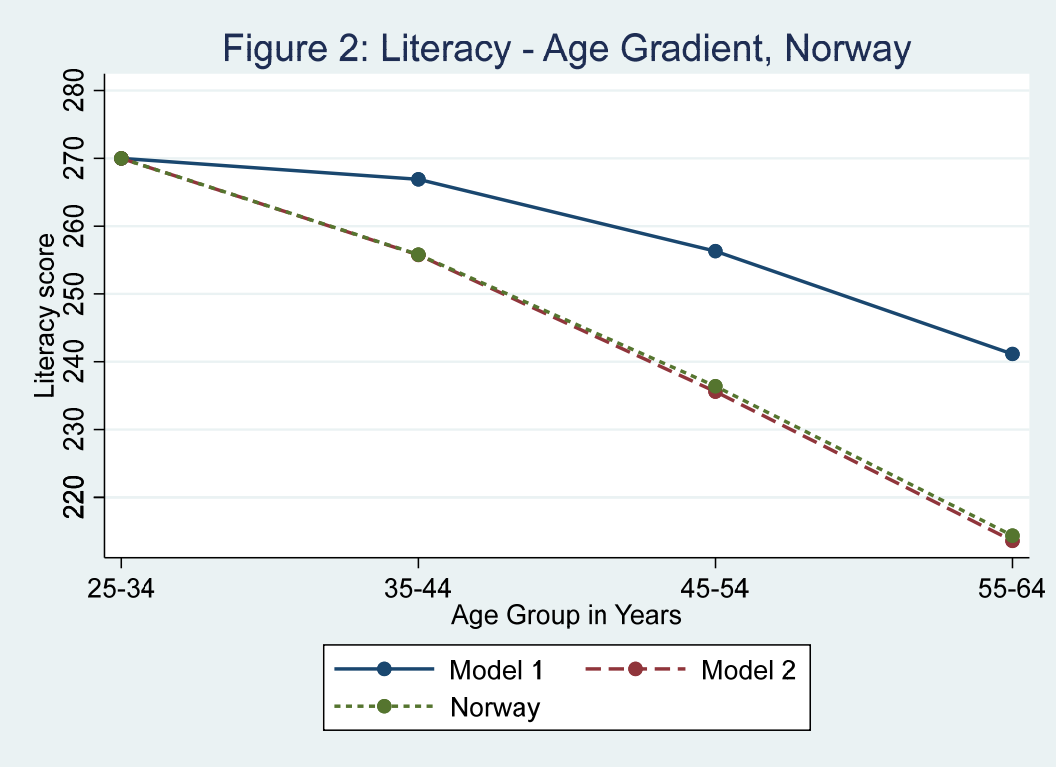
Figure 2: Literacy - Age Gradient, Norway
Literacy score
220
230
240
250
260
270
280
25-34
35-44
45-54
55-64
Age Group in Years
Model 1
Model 2
Norway

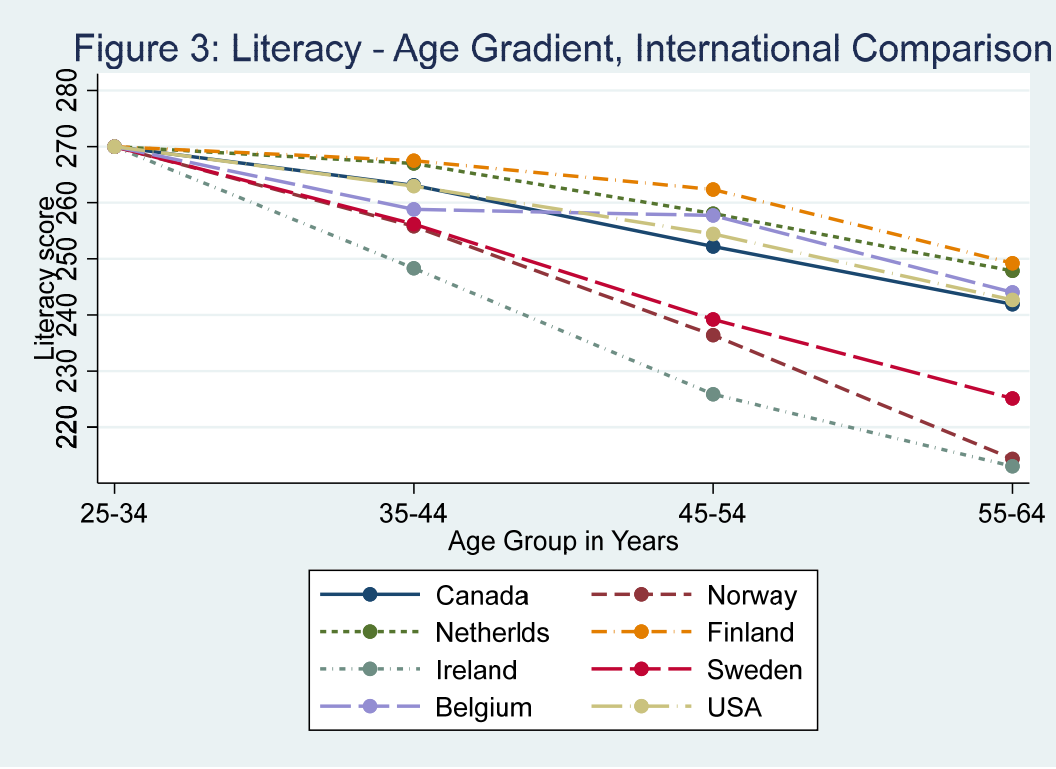
Figure 3: Literacy - Age Gradient, International Comparison
Literacy score
220
230
240
250
260
270
280
25-34
35-44
45-54
55-64
Age Group in Years
Canada
Netherlds
Ireland
Belgium
Norway
Finland
Sweden
USA

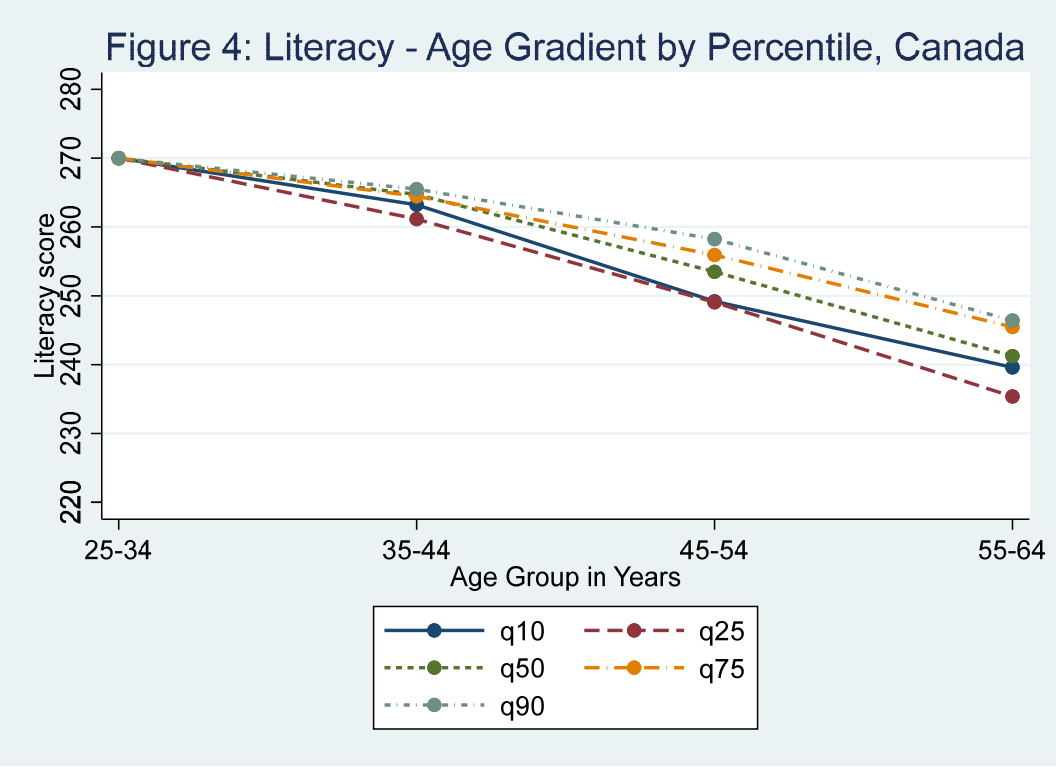
Figure 4: Literacy - Age Gradient by Percentile, Canada
Literacy score
220
230
240
250
260
270
280
25-34
35-44
45-54
55-64
Age Group in Years
q10
q50
q90
q25
q75