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# Live Longer, Work Longer?

Evidence from Sweden's Ageing  
Population

Haodong Qi

LUND STUDIES IN ECONOMIC HISTORY 75



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# Live Longer, Work Longer?

## Evidence from Sweden's Ageing Population

by Haodong Qi



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DOCTORAL DISSERTATION  
Faculty opponent: Peder J. Pedersen

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# Live Longer, Work Longer?

## Evidence from Sweden's Ageing Population

by Haodong Qi



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*Dedicated to my parents*  
*Xiaowei Gao – Hongwu Qi*



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*Haodong Qi*

Lund, 2016-1-28





# Summary

Sweden's elderly population is growing, propelled by a continuous decline in old-age mortality, while coupled with a persistent replacement level fertility. This changing age structure increases the per worker cost of providing a given age-vector of per capita benefits, encompassing costs for pensions, health care, and all other type of old-age welfare services, which presents a looming challenge for the welfare state to sustain its social transfer system. Options for tackling this daunting challenge, such as increasing fertility and immigration levels, cutting benefits and growing public debts, present numerous obstacles, thus discussion of policy options has shifted the focus towards extending working life. This book contributes to this ongoing policy discussion by exploring the recent trends in labor supply, and investigating the underlying mechanisms driving these trends. The results of this work illustrate a recent trend of prolonging working life in Sweden, whereby average labor income has increased at older ages, and younger cohorts have increasingly postponed their retirement. While these changes are uniform across individuals of different sexes, occupations, and educational levels, the underlying mechanisms appear different. These micro mechanisms may have myriad implications concerning aggregate economic support for the ageing Swedish population. In this regard, the findings in this book are relevant inputs for assessing the welfare consequences of population ageing and deriving evidence-based policy options.



# Chapter I

## Introduction

### I Motivation and Aim

The world's population has been growing older, and it will continue to do so in the coming decades, a process commonly referred to as population ageing. Today, the share of the global population aged 60 years or older has reached 12.3%, and is expected to more than double (28.3%) by the end of this century. Europe and North America are now the “oldest” continents in the world, with nearly a quarter of the population aged 60 years or older, while Asia, Africa, Latin America and the Caribbean, and Oceania are slightly younger (United Nations, 2015). Not only is the ageing process likely to continue among those oldest nations, but it will also evolve more rapidly in areas where the age distribution is still young. For instance, the former “oldest” countries with median ages around 35 in the 20th century (including Austria, Belgium, Germany, France, and Sweden) will be replaced by latter “oldest” nations (including Korea, China, Singapore, and Hong Kong) with median ages around 53 in the forthcoming decades (United Nations, 2015). Hence, population ageing is a global phenomenon.

Fundamental demographic theory suggests that the age structure of a population will stabilize if birth and death rates stay constant (Preston et al., 1989, 2001). Therefore, the conventional belief in the causes of population ageing is the transition from high to low fertility and mortality. However, while the net effect of fertility decline is unambiguously positive on population ageing, the mortality de-

cline is ambiguous, depending on the change in the age-specific survival (individual ageing effect) and the initial level of mortality (Lee, 1994). As most reductions in death rates were initially concentrated at younger ages, it was not until recently that improvements in survival after age 65 propelled the increase in human life expectancy (Oppen and Vaupel, 2002), thus the initial driver of population ageing was, in fact, fertility decline, but not mortality decline.

The reduction in premature death together with falling fertility constituted the first stage of population ageing (Bengtsson and Scott, 2011), which brought important implications for economic development. More survivors at young ages and resources devoted to childrearing, e.g. women's time, were transformed into productive activities (Livi-Bacci, 2000). As a result, the initial process of population ageing exerted a positive effect on the ratio of productive to non-productive age population (demographic support ratio), and, in turn, stimulated economic growth, a phenomenon often referred to as the first "demographic dividend" (Bloom and Canning, 2009; Mason, 2005; Mason and Lee, 2007; United Nations, 2013). A demographic dividend, or an economically favorable population structure, created the possibility for the rise of a generous welfare state. Particularly in Europe during the period between the end of World War II and the early 1970s, workers were much more abundant relative to non-workers, which favored the creation of generous welfare system providing pensions and various social services (Livi-Bacci, 2000).

Despite that the first stage of population ageing was primarily driven by fertility decline, the second stage of this process will be largely induced by continuous improvements in old age life expectancy (Bengtsson and Scott, 2011). In other words, the cause of demographic ageing will shift from fertility decline to mortality decline at older ages, which is or will soon be occurring in Europe as well as many other developed countries. The second stage will propel rapid growth in the share of the elderly aged 60 or 65+ relative to the effective workforce, meaning the demographic support ratio will decline. This implies that the per worker cost of providing a given age vector of per capita benefits will increase (Lee and Edwards, 2001). These benefits are generally to support those who are at dependency stages over the life-cycle, when consumption exceeds production (income). The difference between consumption and production is the life-cycle deficit, which is usually large and positive for children and elderly; and they are only possible if inter-generational transfers are facilitated in the economic system. That is, age groups at dependency stages are sustained by flows of resources from those at pro-

ductive stages (Lee, 1994). These flows may be mediated by private or public institutions, such as families, governments, markets, and charitable organizations. Flows toward children are overwhelmingly private, despite education often being publicly financed, whereas flows toward elderly are much more complex across economies and societies.

In Europe, the old-age support system is much more reliant on public transfers, compared to the systems in other industrialized economies, such as in Japan and the US (Mason and Lee, 2011). Among all the European states, Sweden stands out as one of the extreme cases<sup>1</sup>, where the deficits among the elderly are entirely funded through public channels, with little through private transfers and asset income (Hallberg et al., 2011; Mason and Lee, 2011; United Nations, 2013).

While the life-cycle hypothesis predicts that consumption stays fairly constant over the life-cycle (Jappelli and Modigliani, 2005), the per capita age-consumption profile in Sweden presents a strong tilt towards old age, with the level nearly doubling between ages 80 and 100. And the tilt is mainly due to old-age health expenditure, which is largely mediated by flows via the public channel in Sweden (Hallberg et al., 2011). When the share of the elderly population grows, the existing consumption pattern and the public transfer system may exacerbate an expansion of public deficit, which, therefore, presents a challenge for the welfare state to sustain the public finance system.

To cope with the potential growth in deficits, integrated policy is of great importance, and needs to be in place before the challenges become too big to manage. Squeezing public consumption, such as benefit cuts, may be one of the possible solutions. This, however, will translate into welfare loss, and consequently deteriorates overall economic efficiency, as welfare services are pushed into home production, which may, in turn, lower labor market participation. Additionally, since the dominating part of public consumption over old age in Sweden is related to health expenditures, squeezing such consumption may also have negative implications for general population health, or perhaps even mortality, and is therefore undesirable.

Of course, deficits may always be financed through credit creation. However, recent debt crises felt throughout Europe cast doubt on the possibility for further debt issuance. Even though debt can be issued, it still needs to be repaid by future

---

<sup>1</sup>Other European countries, where elderly rely most heavily on public transfer, include, but not limited to, the Nordic region, Austria, Slovenia (see page 22 in Mason and Lee (2011)).

generations, thus the inter-generational equity issue remains. Public debts may also crowd out private investment, which is detrimental to productive activities, unless Ricardian Equivalence Proposition holds (Barro, 1974). Alternative options may be increasing tax revenue, by either raising tax rate, or by expanding the tax base. The former, however, is less feasible in Sweden because the tax level is already very high by international comparison, about 60% of GDP per capita (Hallberg et al., 2011). Therefore, a more reasonable alternative may be to broaden the tax base.

Demographic measures may help expand the tax base, such as policies facilitating childbearing and/or immigration, which may have the potential to maintain the size of the labor force. Increasing fertility, however, would take at least 2-3 decades to see a positive effect on the tax base expansion (Bengtsson and Scott, 2011). An economically- and socially-desirable outcome of immigration is the success with which foreign-born workers integrate into the labor market. A poor integration of immigrant workers may, however, create additional burdens for the ageing society.

As the above-mentioned options present numerous obstacles in expanding the tax base, recently proposed solutions have shifted the focus towards extending working life. This could be accomplished by early career development, longer working hours, and/or postponing retirement, the so-called “Live Longer, Work Longer” as suggested in Bengtsson (2010) and OECD (2006). However, what needs to be addressed is the challenge of what policy options may encourage the ageing labor force to work longer?

Health expenditures, along with pension provisions, comprise the bulk of spending on an ageing society. Since cutting health expenditures may result in adverse impacts on population health, many governments have chosen pension reform as a measure of mitigating the financial pressures on their social welfare systems. These reforms have generally increased statutory retirement age and stringency of early retirement schemes, and created financial incentives for working longer (OECD, 2013). Sweden underwent several pension reforms during the closing decade of the twentieth century. Major reforms include abolishing the retirement path through Disability Insurance (DI) for labor market reasons, increasing the stringency of admission to DI, and phasing in the notional defined contribution schemes through the 1994 legislation of pension reform. All these policy amendments aimed at facilitating a prolongation of working life. A remaining question is whether the goal of these reforms has been realized.

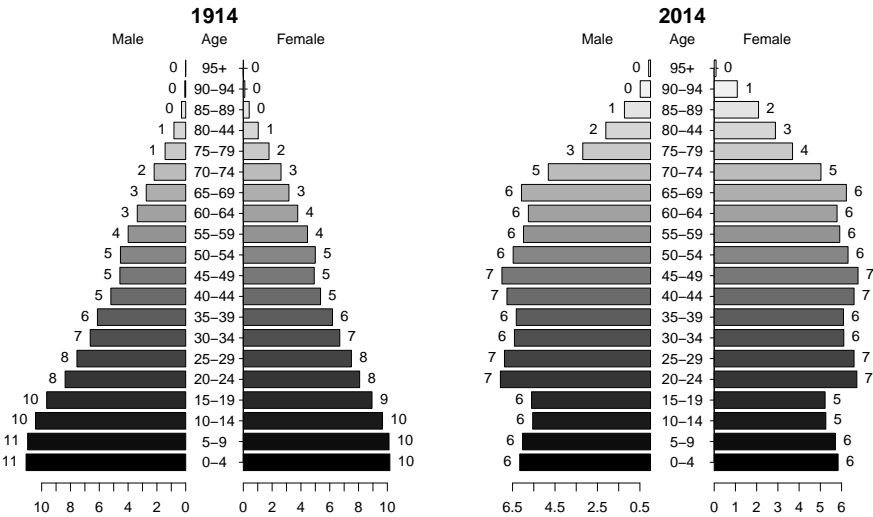
This dissertation, as its title suggests, addresses a question of whether we work longer, as we live longer. It explores trends in labor supply in Sweden during the past decades, and investigates the underlying mechanisms driving these trends. While knowledge about the macro-level trends in employment and retirement have been well established, less is known about whether these aggregate changes are common across different socio-economic and demographic groups. Such knowledge is of importance for assessing the welfare consequences of population ageing, as changing labor supply of individuals may have myriad implications concerning aggregate economic support for the ageing society. This work, therefore, uncovers the differences in the changing patterns of labor supply across individuals of different sexes, education, occupations, and health.

Policies facilitating longer working lives, such as pension reforms, often treat workers in the same way. However, little is known about how different socio-economic groups are affected by these “work longer” policies. Therefore, an even more ambitious goal of this dissertation is to examine the differences in workers’ responses to institutional changes. A specific focus is given to the 1994 public pension reform in Sweden. Two main reasons provide motivation for such a focus. First, empirical evidence has been relatively scarce regarding the labor supply effects of the 1994 reform, compared to topics of changing rules in disability insurance, despite the former having affected a much broader spectrum of older workers. Second, evidence on how workers responded to this reform is of great importance for policy-makers, especially those who determined the rules and regulations of the new pension system, providing valuable inputs for evaluating its design.

## 2 Ageing Demography in Sweden

The population age structure in Sweden has undergone a tremendous change over the past century. A century ago, the population pyramid (Figure 1.1 left panel) revealed a triangle shape, with a large younger population at the base and a tapering older population on top. This is a classical pattern typically observed in historical agriculture contexts, as well as in the less developed world today (Bengtsson and Scott, 2011). A century later, the pyramid (Figure 1.1 right panel) has switched from a triangle into an urn shape. The width of the young population at the bottom of the pyramid has narrowed substantially, with the percentage share having dropped by approximately half for under age 20. This lost share of the population is shifting

towards old-age. The share of the population aged 60+ has approximately doubled between 1914 and 2014.

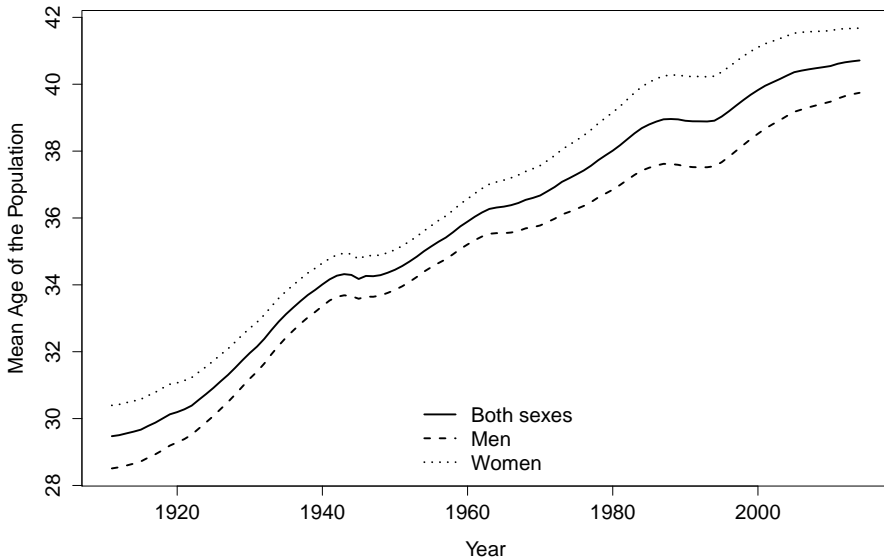


**Figure 1.1:** Population Pyramids for Sweden, 1914 and 2014  
 Note: Own calculation based on Statistics Sweden (SCB); Population Statistics

One of the common indicators summarizing population age structure is the mean age of population (Preston et al., 1989, 2001). Figure 1.2 uses this measure to summarize the transition process of the population pyramid from the triangle shape in the early 20th century to the urn-shape today. As shown in Figure 1.1, the difference in the two pyramids for year 1914 and 2014 implies that the dominating share of the population shifts from the base towards older ages. Such a shifting pattern corresponds with the increase in the mean age of the population during the past century, as shown in Figure 1.2. The mean age grew from 29.5 to 40.7 years old between 1911 and 2014 for the entire population, and from 28.5 to 39.7 for men and from 30.4 to 41.7 for women. These numbers imply that the Swedish population has been ageing by, on average, 1.3 months per annum since 1911.

As discussed previously, the fundamental demographic theory suggests that an ageing population is an unstable population, of which the demographic conditions are changing over time. Thus, the changing mean age of the population can only



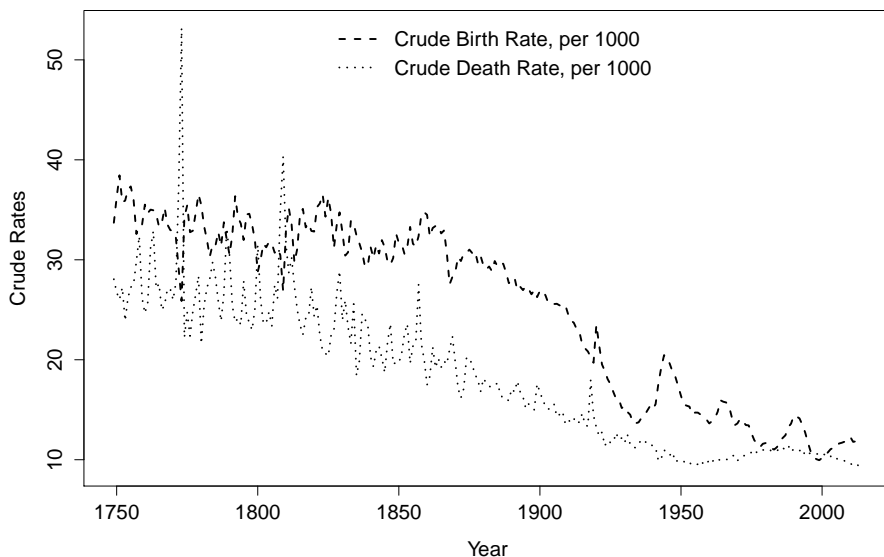


**Figure 1.2:** Mean Population Age, Sweden 1911-2014

Note: Own calculation based on Statistics Sweden (SCB); Population Statistics

arise from changing birth and death rates, assuming the population is closed. As can be seen from Figure 1.3, both birth and death rates have followed downward trends since the mid-18th century. The declining process was particularly profound over the second half of the 19th century and the first half of the 20th century. Such trends indeed imply that the growing mean age of the population, as shown in Figure 1.2, may be related to the decline in mortality and fertility, a relation formally derived in Preston et al. (1989, 2001).

However, as argued in Lee (1994), the net effect of fertility decline is unambiguously positive on population ageing, whereas the impact of mortality decline can be either positive or negative depending on the change in life-cycle survival schedule (the individual ageing effect) and the initial level of mortality. As shown in Figure 1.3, the mortality decline did not accelerate until the mid-19th century, when crude death rates were more than twice as high as today. Hence, when mortality began to decline during the mid-19th century in Sweden, the population was



**Figure 1.3:** Birth and Death Rates, Sweden 1750-2014

Note: Own calculation based on Statistics Sweden (SCB); Population Statistics

actually growing younger because the individual ageing effect was outweighed by the rate of growth effect.

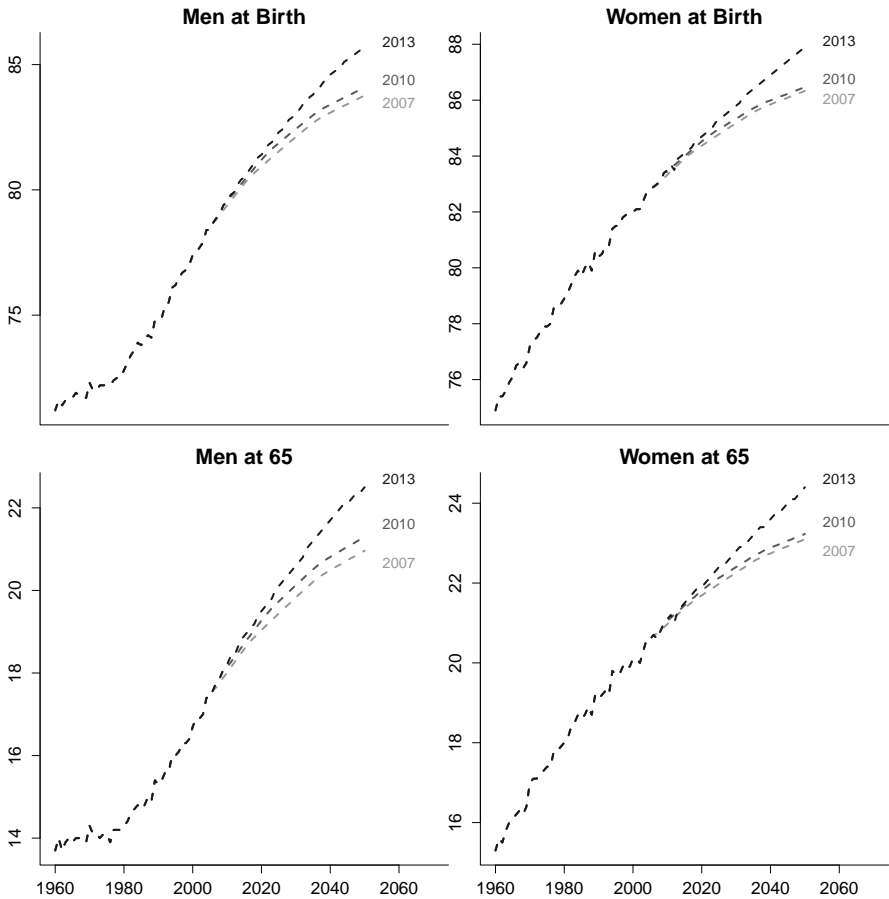
Indeed, Coale (1957) highlighted the overarching importance of fertility decline on the age structure of Swedish population during the period 1860-1950. His exercise showed that the age distribution would have been the same in 1950 as in 1860, had fertility remained at 1860 levels, but mortality declined as it was observed. Conversely, when mortality was held constant, and fertility declined at historical rates, the counter-factual age structure in 1950 was strikingly similar to the actual one. Hence Coale's conclusion is that the population ageing through the first half of 20th century was mainly driven by fertility decline. Bengtsson and Scott (2011) replicated Coale's exercise with data for Sweden during the period 1900-2000, and reached the similar conclusion that population ageing in Sweden was primarily driven by the fertility decline during the entire 20th century, a so-called "first-stage of population ageing".

However, as argued by Lee (1994), the individual ageing effect would dominate the rate of growth effect when the level of mortality is low, which, in turn, let the population grow older. This is indeed the case for the period after 1950 in Sweden. As shown in Figure 1.3, the death rate reached the lowest level and birth rates stabilized (after the baby boomers were born) since the end of World War II. In the meantime, human life expectancy continued to rise, propelled by further improvements in survival after age 65 (Oppen and Vaupel, 2002). Individual ageing, therefore, started to exert an effect on the population age structure. Preston et al. (1989) decomposed the growing mean age of population in Sweden, 1980-1985, and found that mortality decline accounted for 61% and 54% of the increase in the mean population age for men and women, respectively; and declining number of births only explained 4.4% increase for the male population, and even had a negative contribution to the increase for female population. This highlights the importance of mortality decline in the second-stage of population ageing.

Concerning future population development in Sweden, mortality will become a more important determinant than fertility for the population structure. The average number of children born per woman (TFR) has dropped from nearly 5 in 1750 to 1.88 in 2014, a rate of decline about 0.01 per year. However, the speed of decline has slowed down over the past half century, as annual decline in TFR was roughly 0.005 between 1960 and 2014. Thus the birth rate is nowadays likely to oscillate around a constant rate without a trend. Mortality, on the other hand, may be increasingly important for the population structure through the individual ageing effect. The magnitude of such an effect will increase as a growing share of the population enters old age. Hence a relevant question for the future demography of Sweden is how far life expectancy will expand.

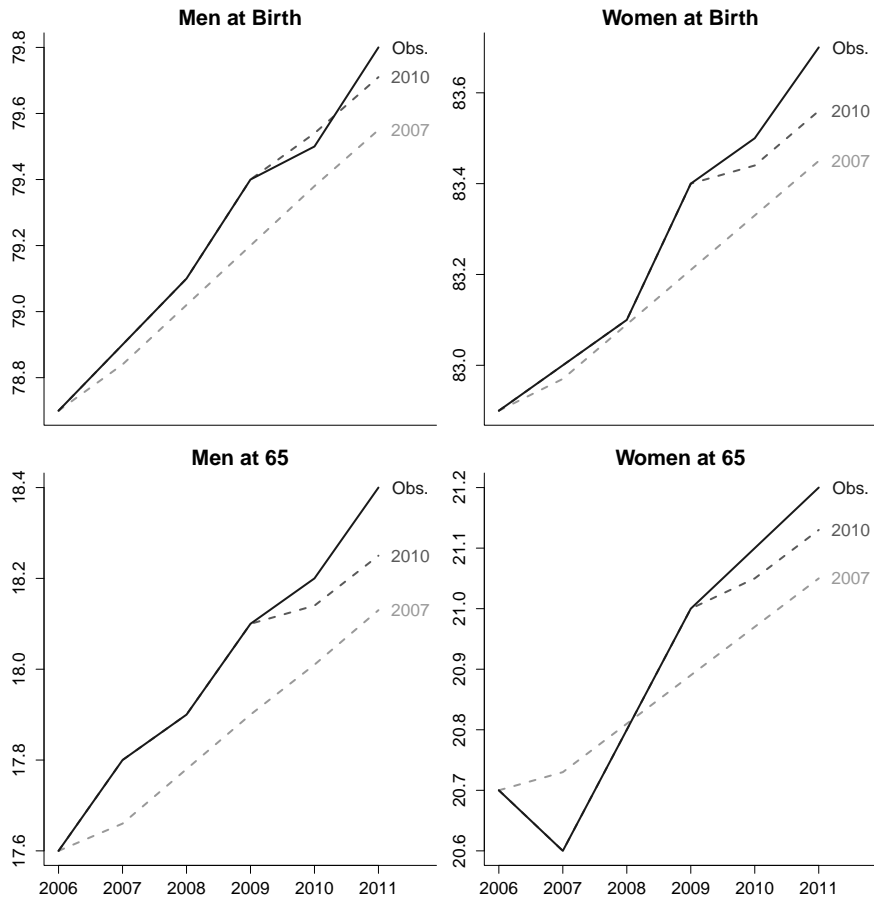
In Sweden, demographic forecasting used to adopt the assumption that the increase in life expectancy will slow down. As shown in Figure 1.4, the remaining life expectancy at birth and age 65 was expected to level off based on 2007 and 2010 mortality projections by Statistics Sweden. Such predictions reflect the expert's assertion that there will be a ceiling for the increase of life expectancy. However, this view, in fact, results in an underestimation of the future mortality development, which can be seen in Figure 1.5. The difference between projected (dash lines in Figure 1.5) and observed (solid line in Figure 1.5) life expectancy reveals the years in life expectancy being underestimated due to the belief in the limit of human life span. Such faulty assumptions and beliefs are common practice in demographic projections and forecasting. As Oppen and Vaupel (2002) argued, experts have

been repeatedly proven wrong by their repeated assertion that life expectancy is approaching a ceiling.



**Figure 1.4:** Life Expectancy Projection by Statistics Sweden (SCB)

This expectation was altered in the most recent (2013) life expectancy projections, conducted by Statistics Sweden. Life expectancy is predicted to follow a linear growth trend in the coming decades, shown by the dark dash line in Figure 1.4. This is a scenario that is more closely related to the past trajectories of the linear increase in life expectancy. It is also in line with the expectation in Oppen and Vaupel (2002) that longevity is likely to continuously increase. If this linear trend



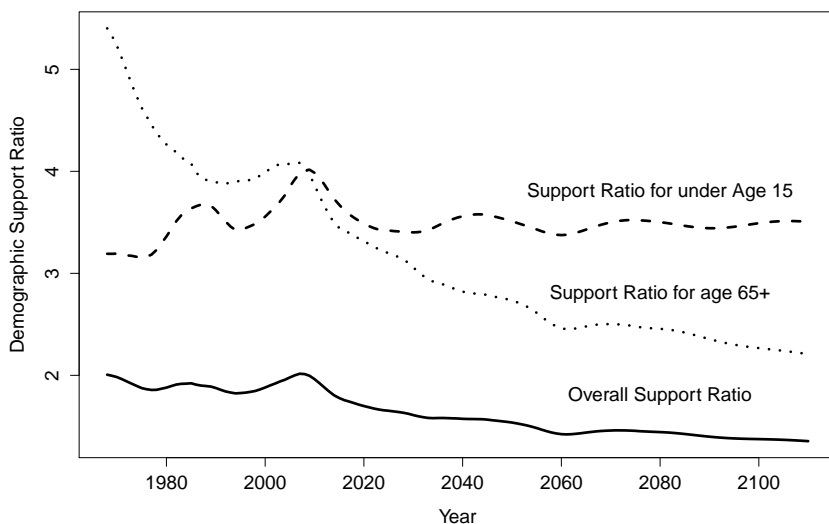
**Figure 1.5:** Observed versus Projected Life Expectancy by Statistics Sweden (SCB)

continues, an ageing society shall expect not only more centenarians, but also more super-centenarians (Harper, 2014). These potential (super) centenarians will result in a further increase of the mean age of the population, as well as reshaping the population pyramid from urn-shape to rectangular.

### 3 Economic Prospects of Population Ageing

The previous sections have reviewed the fundamentals of population ageing. The ageing process over the past century in Sweden is mainly driven by fertility decline rather than mortality. This is because the individual ageing effect did not suffice to alter the population age structure until the late 20th century. The effect of fertility decline, in fact, initially led to a favorable welfare consequence of population ageing. The rapid decline in birth rates outweighed the increased share of elderly over the early 20th century. As a result, the number of workers as a share of total number of dependants (children and elderly) increased, a relation commonly referred to as demographic support ratio. Therefore, the first stage of population ageing was not a problem, but it rather yielded a positive effect on economic development.

However, recent fertility in Sweden has stabilized around replacement level (two children per women), while life expectancy has continued to rise, particularly after age 65. These population dynamics triggered the second stage of population ageing, in which mortality shifted from rejuvenating to ageing the population. As a result, the support ratio is about to decline, and the demographic dividend will be used up and transformed into a deficit. This trend in Sweden is depicted in Figure 1.6 over the period 1968-2110. The inverse of the support ratio reflects the proportion of per capita production by net producers needed to support per capita consumption of net consumers. For example, if the support ratio is 2, the share of per unit production for supporting the net consumer is 50%. The solid line in Figure 1.6 corresponds to the overall support ratio, the total population at working age (15-64) in relation to the total dependent population (under age 15 and over age 64). This ratio has been and will be declining, implying that the proportion of each unit of production to support each net consumer has increased from 50% in 1960 to 56% in 2014, and will continue to rise to 74% in 2110. That is three-quarters of the goods and services produced by workers will need to be transferred to non-workers in the beginning of the next century.



**Figure 1.6:** Demographic Support Ratio, Sweden 1968-2110

Note: Own calculations based on 1-year-group age-specific population data 1968-2014 and 1-year-group age-specific population projection 2015-2110, Statistics Sweden

The overall support ratio can be broken down by two counter-factual scenarios: an economy with net consumers either under age 15 or above age 65. These two scenarios are illustrated by the dash and dotted lines. When an economy only has net consumers under age 15, the proportion of per unit production needed to finance the consumption of the young population is merely 27% in 2014, and will be 28.5% in 2110. However, this percentage share would be substantially higher if an economy only had net consumers above age 65. As shown by the dotted line, only 18.5% of per unit production was needed for each net consumer's consumption in 1968. This share has increased to nearly 30% today and will be up to 45% in less than a century.

The latter scenario is essentially the Samuelson type of overlapping generation economy, in which only two generations, worker and retirees coexist (Samuelson, 1958). The optimal population growth theory suggests that the increase in the support ratio expands the tax base for inter-generational transfers given the to-

tal pension expenditure, and therefore yields a positive impact on overall welfare (Samuelson, 1975). The downward trend of the dotted line, however, implies the opposite situations, that the support ratio decreases, and thus adversely influences economic welfare. This leads to the main concern: will the Swedish welfare state be able to maintain the standards of living once net producers become more scarce relative to net consumers?

It is important to stress that the interpretation of the demographic support ratio relies on the assumption that the economy uses labor as the only production factor, without potential improvement in the quality of labor and technology. This assumption is, however, unrealistic. According to the technophysio evolution theory, the synergy between technological and physiological changes over the past three centuries enabled humans to live twice as long with larger and healthier bodies, which, in turn, accelerated economic growth and technological advances (Floud et al., 2011; Fogel, 2004b,a; Fogel and Costa, 1997). These evolutionary changes imply that the output from one generation to the next may increase, as the physiological condition of the later born generation has improved relative to their older counterparts, which determines their capability of work, as well as shapes the growth of the economy. When interpreting the demographic ratio, we also assume that the amount of goods and services produced and consumed are constant over the life-cycle. This is, again, an unrealistic assumption, as Figure 1.7 shows that neither production, nor consumption is constant across ages<sup>2</sup>.

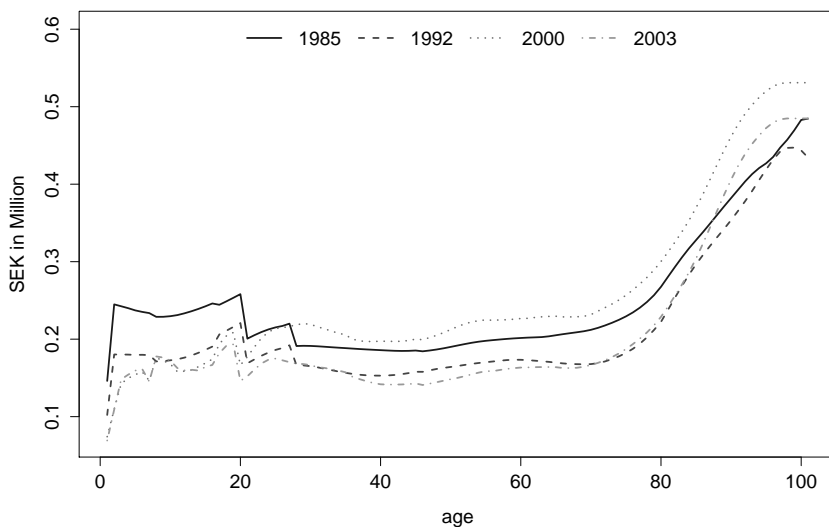
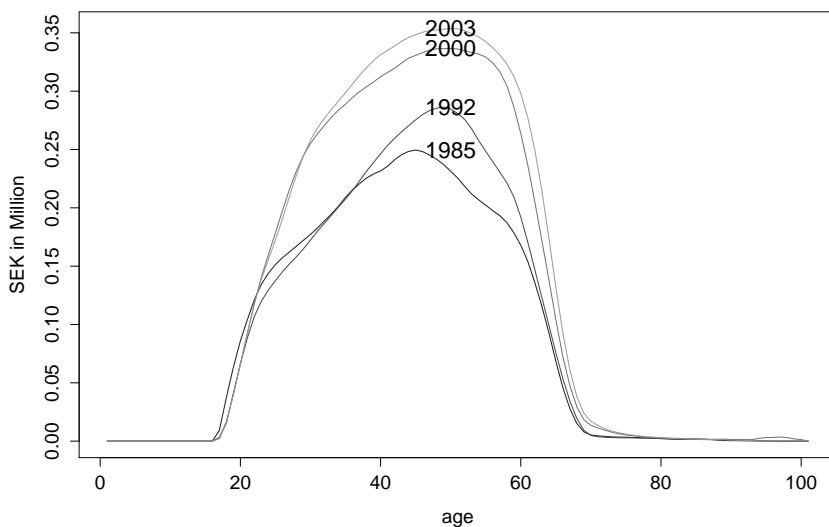
The hump-shaped age profile, shown in the upper panel of Figure 1.7, may reflect the labor productivity differential with respect to age, as suggested in Skirbekk (2003), whereby labor productivity sharply increases since the entry age to the labor market, peaks around age 50, and gradually declines thereafter. This pattern is widely observable, and can be found in 17 out of 19 OECD countries<sup>3</sup>. On the other hand, the hump-shaped income age profile may also relate to varying working behavior throughout the lifetime. Such behavior may depend on culture, institutions, preference for leisure and consumption, and so forth (Lee and Mason, 2011).

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<sup>2</sup>Figure 1.7 decomposes the total income and consumption in the national economy (from national accounts) by age groups and weights them by age-specific population. For detailed construction of these age profiles, see Lee and Mason (2011); United Nations (2013).

<sup>3</sup>These countries are Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Mexico, The Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland and the U.S.



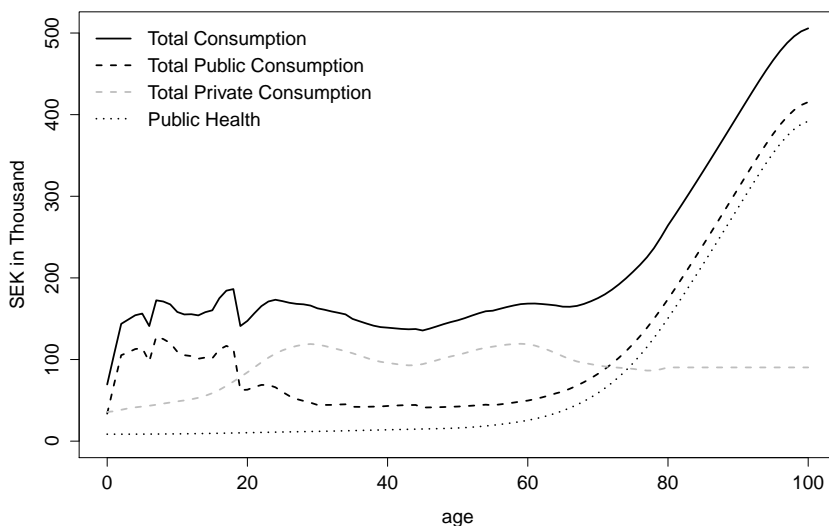


**Figure 1.7:** Life-cycle Labor Income and Consumption, Sweden 1985-2003  
Source: National Transfer Accounts (NTA), Sweden 1985-2003

The life-cycle hypothesis provides a theoretical prediction that the age profile of consumption shall be flat; and empirical evidence in Jappelli and Modigliani (2005) suggests that the pattern is slightly hump-shaped and correlated with conventional disposable income. Such a hump-shaped consumption profile is commonly observable in many economies, for example Spain, South Korea, Mexico, Chile, Uruguay, Costa Rica, Thailand, Indonesia, China, Philippines, India, Nigeria, and Kenya (Tung, 2011). The age-profile of consumption for Sweden, however, is in sharp contrast to the above-mentioned economies as well as the life-cycle hypothesis prediction. As shown in the lower panel of Figure 1.7, the age profile is neither flat, nor hump shaped.

The main feature that distinguishes the Swedish life-cycle consumption pattern is the tilt towards old age, whereby per capita consumption is nearly doubled between age 80 and 100. As argued in Lee et al. (2011), such a sharp increase in old age consumption exacerbates the challenge of financing the cost of an ageing population. To explore the increase further, total consumption is decomposed into private and public, as shown in Figure 1.8. It is evident that the age profile of private consumption (grey dash line) is much flatter and slightly hump-shaped. This is in line with the life-cycle hypothesis prediction and similar to other economies mentioned earlier. The age distribution of public consumption is nearly identical to total consumption, therefore the sharp increase in old age total consumption is mainly driven by the public component. Having further decomposed the public consumption into education and health expenditure, it becomes clear that the sharp increase in consumption over older ages is mainly attributable to public health. This consumption pattern also reflects the unique institutional settings of the redistribution system in Sweden. Unlike many other advanced economies, Swedish intergenerational redistribution is largely mediated through the public sector, and the bulk of it is on health care (Hallberg et al., 2011). This also explains the consumption tilt towards old age. Such high expenditure further exacerbates the concern of whether public budgets can be balanced in the long run when the population is rapidly ageing in the coming decades.

Production and consumption age profiles, as shown in Figure 1.7, altogether constitute the economic life-cycle. Typically people consume more than what they produce when they are young and old (the net consumer), and produce more than what they consume throughout prime working ages (net producer); and the interaction between the economic life-cycle and the structural dynamics of the population gives rise to the generational economy (Lee and Mason, 2011). How



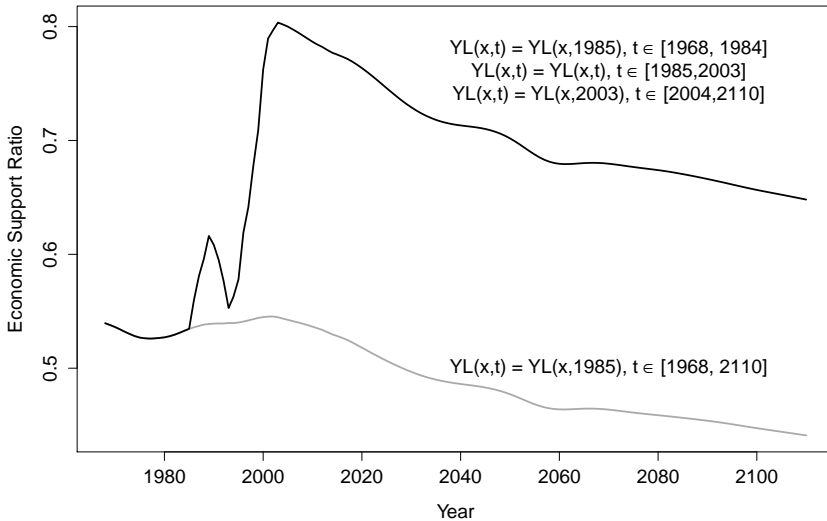
**Figure 1.8:** Decomposing Consumption Age Profile, Sweden 2003  
Source: National Transfer Accounts (NTA), Sweden 2003

well the generational economy functions is of great importance, as it may not only affect the standard of living among the concurrent generations, but also future ones whose output is partly determined by its inheritance from past generations (Floud et al., 2011).

An additional strong assumption in the support ratio is that it uses an arbitrary age threshold to distinguish between the economically active and inactive population (Prskawetz and Sambt, 2014). When the demographic ratio is related to the economic life-cycle, the arbitrary assumption of age limits are no longer needed. It then translates the amount of total support into monetary terms by interacting the age-specific population data with the age profiles of income and consumption. This indicator is called the Economic Support Ratio (ESR), which provides the potential for evaluating the amount of resources necessary to sustain the standard of living in the context of population ageing. The grey solid line in Figure 1.9 shows a long term decline in ESR for Sweden 1968–2110, given the assumption that the age profile of labor income and consumption stays constant as in 1985 over time<sup>4</sup>.

<sup>4</sup>The method for calculating economic support ratio can be found in Prskawetz and Sambt (2014)

This trend suggests that by year 2110, the ESR will drop to 0.44, meaning that the total production in the economy will only cover 44% of total consumption. In other words, maintaining the consumption pattern as in 1985 would result in a deficit that is more than double total income.



**Figure 1.9:** Economic Support Ratio, Sweden 1968-2110

Note: Own calculation based on National Transfer Accounts (NTA), Sweden, and one year age group population data 1968-2110, Statistics Sweden.

Squeezing consumption may be the most obvious solution to reduce the deficit. This, however, will translate into the loss of utility and welfare which is economically and socially unfavourable. Moreover, as shown in Figure 1.8, the sharp increase in old-age consumption is mainly driven by public health expenditure. Cutting such consumption may result in huge implications not only for standards of living, but also population health, or perhaps even mortality, and are therefore undesirable. Hence, to finance such growing cost requires increasing tax revenue. Two ways are fundamentally available for this: expanding tax base and/or increase tax rate. Tax burden in Sweden has already been heavy, about 60% of GDP per capita (Hallberg et al., 2011). Thus a more reasonable alternative is to broaden tax base.

Demographic measures may be helpful to expand the tax base, such as pursuing family friendly policy to facilitate childbearing, and/or immigration policy to maintain the size of the labor force, and possibly improve competitiveness and productivity (Harper, 2014). Increasing fertility, however, would take at least 2-3 decades to see positive effect on the tax base expansion (Bengtsson and Scott, 2011). A desired outcome of immigration, on the other hand, depends on whether foreign workers could integrate into the labor market to fill the demand. A poor integration of immigrants to the labor market may create additional burden of the ageing society. Therefore, options left for counteracting the potential decline in economic support seem to be on the production side.

Not only does Figure 1.7 show us the shape of the life-cycle production and consumption, but it also reveals the changes in these age profiles over time. Comparing the upper and lower panel in Figure 1.7, it is evident that the changes are much more profound in the labor income profiles than the consumption ones. The changing shape of the labor income is mainly characterized by a right shift towards old age. To explore the importance of the life-cycle labor income for the ageing economy, I calculate the Economic Support Ratio using the time-varying labor income profiles (as shown in Figure 1.7) and age-specific population data (observed up to 2014 and projected to 2110) from Statistics Sweden. The results are shown in Figure 1.9.

The grey solid line in Figure 1.9 corresponds to the projection scenario that labor income will stay as low as the 1985 level (shown in Figure 1.7). The dark solid line over the period 1985 and 2003 corresponds to the observed economic support ratio calculated based on the observed yearly age profiles of labor income and consumption, and the observed population data. For the period after year 2003, the age profiles in year 2003 are imposed. The difference between the dark and grey solid lines reflects the effect of the shifting labor income profile towards old age on the economic support ratio. For example, if the age profile of labor income stays constant as in 1985, only 54% of consumption would have been financed by total production in year 2003. In other words, 46% would have been under financed. Given the realistic time-varying labor income profiles, the share of under financed consumption is reduced to 20% in 2003. In the long run, if the life-cycle labor income is kept as in 1985, given the prospective ageing population, the economic support ratio will drop to 44%, which translates to more than half of consumption being under financed. Nevertheless, letting the labor income profile shift towards old age, as it had been from 1985 to 2003, reduces the under-financed proportion

of consumption from 56 to 35%. This simple exercise implies that increasing the labor income in later life may effectively mitigate the future increase in deficits. But the next question is: how can old-age labor income be increased?

The per capita values of labor income, as plotted in Figure 1.7, are simply the total market value of labor supply weighted by all members, both employed and unemployed, of a population in a particular age group (Lee and Ogawa, 2011). Formally this may be written as:

$$yl(x) = \frac{YL(x)}{P(x)} \quad (1.1)$$

where,  $yl$  is the per capita value,  $YL$  is the aggregated labor income,  $P$  is population size,  $x$  is age

If, for any particular age group, there is no unemployment,  $yl$  is equivalent to the equilibrium wage rate at the market clearing level with full employment. However, unemployment always exists, thus the aggregate labor income  $YL$  may be written as a function of de facto wage rate and number of employed persons. That is:

$$YL(x) = w(x)E(x) \quad (1.2)$$

Substituting (1.2) into (1.1), the age-specific per capita labor income may be written as a product of de facto wage rate and employment rate for a particular age group.

$$yl(x) = \frac{w(x)E(x)}{P(x)} = w(x)e(x) \quad (1.3)$$

From the above simple relation, one might argue that the shifting labor income profile towards old age may be achieved by increasing the labor productivity (assuming wage rate  $w(x)$  equals to marginal product of labor), and/or work participation ( $e(x)$ ) among older workers. As shown in Figure 1.9, despite using the 2003 age profile of labor income result in a much higher ESR than using the 1985 age profile, the shifts in labor income towards older ages will still not suffice to balance the budget, and about 35% of total consumption will still remain under financed in 2110. As stressed earlier, issuing debt and/or increasing tax rates will become more difficult, thus shifting the labor income profile further right towards older ages may be a potential solution. This dissertation gives particular focus to the work participation component in (1.3). More specifically, it stresses on the prolongation of working life, a topic that is increasingly gaining attention.

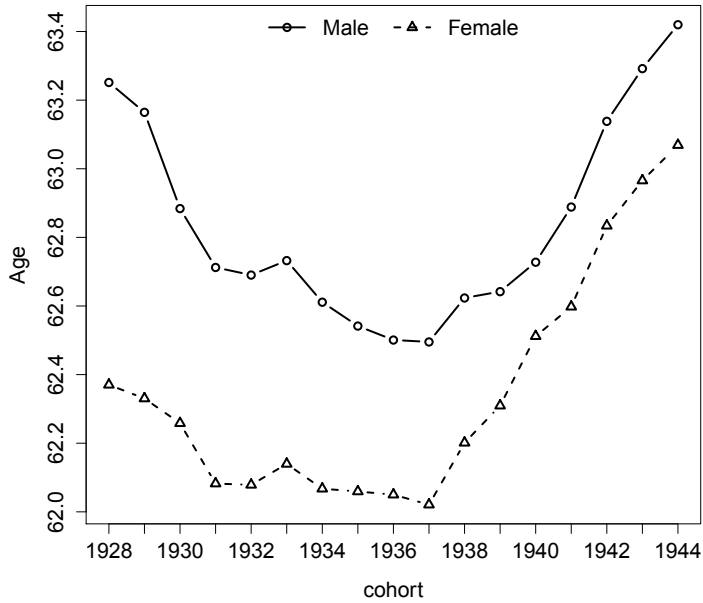
## 4 Live Longer, Work Longer?

As we live longer, have we worked longer? Evidence across OECD nations suggests a negative answer, as the effective retirement age has declined substantially since 1970, which, in most countries, is well below the statutory retirement age, at which a full old-age pension is available (OECD, 2006). However, this declining trend was interrupted around the early 2000s, and since then the effective retirement age has gradually increased (OECD, 2013).

Sweden, like many other OECD countries, also witnessed a trend decline in mean retirement age up until the mid-1990s, and has experienced a gradual upturn over the last two decades. Recent statistics show that the average age exiting the Swedish labor market has grown from 63 to 64 years old during the period 2000-2011, an extended working life for about one month per year (Karlsson and Olsson, 2012). Such a trend reversal can also be seen with a cohort perspective. As shown in Figure 1.10, the effective retirement age declined across cohorts born between 1928 and 1937, and increased among those born between 1938 and 1944. This cohort trend reversal was also uniform across different sexes, as changes for men and women occurred in near-parallel fashion.

While both the changes over time and across cohorts suggest the existence of a recent trend towards prolonging working life in Sweden (Karlsson and Olsson, 2012), less is known about whether this experience of working longer is universal across different socio-economic groups. Such knowledge, however, is crucial to develop an understanding of how population ageing will affect the welfare state, as changing micro-level labor supply behavior may have myriad implications for aggregate economic support. Hence, this dissertation sheds some new light on the differences in prolongation of working life across individuals of different educational levels, occupations, countries of origin, and health status.

In addition, the trend reversal in the effective retirement age across many OECD countries has been widely viewed as a result of governments' interventions (Buchholz et al., 2013; Komp et al., 2010), such as making the admission to early retirement schemes increasingly stringent, raising statutory retirement ages, creating financial incentives through adjusting benefit accounting, and so forth. However, these interventions are quite often applied uniformly for all workers, without differentiating the policy treatment with respect to different socio-economic groups. Therefore, it is unclear whether the institutional reform can fully explain



**Figure 1.10:** Mean age at retirement by cohort, conditioning on population who are still in the labor force at age 50.

Data Source: Swedish Inter-disciplinary Panel (SIP).

Note: Retirement is defined if the worker has no labor income during a calendar year.

the changing labor supply for all workers. In this regard, the present dissertation contributes to the literature by examining the differential impacts of pension reform on working life extensions.

## 5 Recent Pension Reforms in Sweden

There were three major reforms on the Swedish pension system during the 1990s, two of which targeted Disability Insurance (DI) and the other aimed at the public old-age pension system. The first policy change on Disability Insurance (DI) was implemented in 1991, which abolished the retirement path through DI for labor



market and social condition reasons (Hagen, 2013). In 1997, DI further raised the stringency of admission by eliminating the favorable rule for workers aged 60-64 in 1997.

Karlström et al. (2008) showed that the labor force participation rate increased right after the 1997 amendments on DI, and therefore interpreted this policy change as positively impacting labor supply. However, the analysis in Karlström et al. (2008) ended in 2001, thus it remains unclear whether the postponement of retirement since 2000 is attributable to the abolishment of the DI favorable rule. Additionally, there is an empirical challenge in identifying the labor supply effects of the 1997 DI amendments after 2000, as such effects may potentially confound with the effect of public old-age pension reform, which was legislated in 1994 and implemented by 1999. This issue however has been seldom addressed in the empirical literature. For example, Johansson et al. (2014) and Glans (2008) found a strong and significant effect of the 1997 DI reform and 1994 old age pension reform on retirement rates, respectively. Nevertheless, their estimation is based on the sample exposed to both policy changes, and thus the findings could possibly exaggerate the labor supply effect of each policy amendment. Part of this dissertation addresses this issue by selecting the control and treatment group in a more precise manner.

The 1994 pension reform phased out the defined benefit pay as you go (ATP) by a notional defined contribution pay as you go scheme (NDC). The new scheme started implementation in 1999 and the first benefit was paid out in 2001 (Hagen, 2013). There was a gradual transition from the ATP to NDC. Those born in 1938 were the first cohort who were partially affected by this reform, whereby one-fifth of their pension entitlements was calculated based on the NDC rule, and the remaining share was based on the old ATP rule. The fraction of the benefit based on NDC accounting increased by 5% for each successive birth cohort up to the 1953 one. For those born in 1953 or later, their pension is accounted by a complete conversion of the accumulated pension credits from ATP into NDC (Hagen, 2013; Konberg et al., 2006; Palmer, 2000; Settergren, 2001). The benefits from ATP will be completely phased out by year 2040 (Sunden, 2006).

The rules of benefit accounting are saliently different between ATP and NDC. The benefits in ATP were calculated based on the best-15-year earnings during the working life, which gave no incentive for workers to postpone retirement, because the final benefit would not increase with age, as the peak of the life-cycle earn-

ing usually occurred before age 50 (Laun and Wallenius, 2015). However, labor earnings over the years before retirement will matter substantially for the pension entitlements in NDC simply because the benefit accounting in NDC takes entire working history into account. Moreover, unlike ATP, NDC incorporates a divisor for calculating the annuity, which is a function of remaining life expectancy determined by age and cohort. This design creates stronger incentives than ATP for late retirement because more years working results in more accumulated pension credits, and fewer years of remaining life expectancy in the divisor. In short, the pension income was a very flat function of age in ATP, whereas it became a steep increasing function of age in NDC (Laun and Wallenius, 2015; Palmer, 2000). For example, retiring at age 66 would result in a 9% increase in monthly pension, and retiring at age 67 would lead to nearly a 20% increase, compared to retiring at age 65 (Konberg et al., 2006). Therefore, the 1994 pension reform indeed created strong financial incentives for prolonging working life. This dissertation will explicitly examine whether the trend reversal in the effective retirement age, as shown in Figure 1.10, was a result of incentives created through the 1994 pension reform. In addition, how different socio-economic groups were impacted by this reform were also examined.

## 6 Modelling Retirement

Retirement is conventionally regarded as a discrete choice between working and retiring, whereby the decision to retire is taken if, and only if, the associated utility exceeds the utility of the alternative choice (working). This can be generally written as:

$$\begin{aligned}
 \Pr(R) &= \Pr(U_R > U_W) \\
 &= \Pr(V_R + \epsilon_R > V_W + \epsilon_W) \\
 &= \Pr(V_R - V_W > \epsilon_W - \epsilon_R)
 \end{aligned} \tag{1.4}$$

where,  $R$  is the retirement state,  $W$  is the working state,  $U$  is the utility of either retiring or working, which may be broken down into the deterministic part of the utility ( $V$ ) and the unobserved part of utility ( $\epsilon$ ).

The last equation in (1.4) implies that the probability of retiring is essentially the cumulative density function of the unobserved utility difference between working and retiring ( $\epsilon_W - \epsilon_R$ ) that is less than the difference in the observed utility between

retiring and working ( $V_R - V_W$ ). Let  $\xi_V$  be the value difference  $V_R - V_W$  and  $\xi_\epsilon$  be the difference of two random errors  $\epsilon_W - \epsilon_R$ , thus the probability in (1.4) may be re-written as:

$$\Pr(R) = \int I(\xi_V > \xi_\epsilon) f(\xi_\epsilon) d\xi_\epsilon \quad (1.5)$$

where,  $I(*)$  indicates whether the argument,  $\xi_V > \xi_\epsilon$ , is true.  $f(*)$  is a probability density function of  $\xi_\epsilon$ .

Because  $\epsilon_W$ ,  $\epsilon_R$ , and  $\xi_\epsilon$  are unobserved, to compute the probability of retiring requires the integration of  $\Pr(R)|\xi_\epsilon$  over all values of  $\xi_\epsilon$  weighted by the probability density function,  $f(\xi_\epsilon)$ . The integral in (1.5) may be evaluated either by numerical solution or closed form solution. It is well known that the former method is much more computationally intensive than the latter. Therefore, most retirement studies choose the closed form solution to proceed the model estimation.

To derive the closed form solution, three assumptions on  $\epsilon_W$  and  $\epsilon_R$  are needed. First, the two errors are independent of each other. Second, both errors are identically distributed. Third, each of the errors follows a Gumbel distribution (Type-I extreme value distribution). The last assumption is motivated by the fact that the difference between the two Gumbel distributed variables follows a logistic distribution. More explicitly, if  $\epsilon_W$  and  $\epsilon_R$  are independently and identically distributed extreme values, then  $f(\xi_\epsilon)$  is a logistic distribution. Given these three assumptions on the  $\epsilon$ 's, the probability of retiring has closed form corresponding to the logit transformation of the observed utility of retiring and working ( $V_R$  and  $V_W$ ). Therefore, the probability of retiring can be expressed as:

$$\Pr(R) = \frac{\exp(V_R)}{\exp(V_W) + \exp(V_R)} \quad (1.6)$$

(1.6) is commonly used in most retirement studies. What distinguishes various studies from each other is the specification of the value function  $V$  in (1.6). One of the most dominant findings in retirement literature is that the average age at retirement strongly corresponds to the age at which pension benefits are available; and therefore, the most important cause of retirement is economic incentives provided by the social security system (Gruber and Wise, 1999, 2004). Such a conclusion is mainly drawn based on the retirement model, of which the value function may be implicitly written as:

$$V_p = V(YL, OA, \Omega_p) \quad (1.7)$$

The value function in (1.7) is only determined by income source, e.g. wage ( $YL$ ) and pension ( $OA$ ), and therefore it refers to the pecuniary value of retirement, denoted by  $V_p$ . The last term in (1.7),  $\Omega_p$ , denotes the parameter set reflecting the preference for wage and pension in the pecuniary value function. Previous studies which estimated the retirement model with pecuniary value function specified as in (1.7) generally found that pension ( $OA$ ) has a strong positive impact on the value, as well as on the probability of retirement (Gruber and Wise, 1999, 2004; Karlström et al., 2004; Lumsdaine et al., 1992; Stock and Wise, 1990). This positive relationship also implies that the retirement rates spike at age 65 may be largely explained by incentives from old-age social security.

Another popular retirement model stresses on the determinants of labor market exit, namely the social, economic, and demographic differences in retirement ages or probabilities. The value of retirement in this type of model is simply a function of individual characteristics ( $POP$ ) and a set of parameters ( $\Omega_n$ ). The value function may be implicitly written as:

$$V_n = V(POP, \Omega_n) \quad (1.8)$$

Many previous studies have specified the retirement function using (1.8), and generally found that education, health, occupation, marital status, and gender are important determinants of labor market exit behavior (Börsch-Supan et al., 2009; Buchholz et al., 2013; Glans, 2008; Klevmarken, 2010; Komp et al., 2010; Larsen and Pedersen, 2013; Stenberg and Westerlund, 2013).

A third approach of modelling retirement is to simultaneously control for financial incentives and socio-economic differences. This approach was pioneered by Berkovec and Stern (1991), in which, financial incentives, such as wage and pension, constitute the pecuniary value of retirement, while individual characteristics form the non-pecuniary value. The value function in this type of model is then the combination of  $V_p$  and  $V_n$ , which may be implicitly written as:

$$V_{pn} = V(YL, OA, \Omega_p, POP, \Omega_n) \quad (1.9)$$

(1.9) has been used in retirement studies for various countries. For instance, Johansson et al. (2014) studied financial incentives and retirement in Sweden, Berkovec and Stern (1991) examined the behavior of job switches from full-time to part-time as well as transitions to retirement in the US, and Heyma (2004) estimated

a dynamic programming model of retirement behavior among Dutch old workers. From (1.9), it is evident that the overall value of working and retirement may potentially be determined by both pecuniary and non-pecuniary value functions. Accordingly, the probability of retiring, given the closed form in (1.6), may be written as:

$$\Pr(R) = \frac{\exp(V(OA, \Omega_p, POP, \Omega_n))}{\exp(V(YL, \Omega_p, POP, \Omega_n)) + \exp(V(OA, \Omega_p, POP, \Omega_n))} \quad (1.10)$$

The above-mentioned retirement models suggest that differences in retirement behavior may arise from any of the differences in the elements included in the right-hand side of equation (1.10). Such underlying mechanisms imply that the trend reversal over time and across cohorts, as discussed earlier, may be driven by changing labor income, pension, population characteristics, and/or preferences. These mechanisms provide a theoretical framework for the empirical analyses in this thesis which examine the factors driving the trends in prolonging working life, at both aggregate and individual levels.

## 7 Organization of the Thesis

This dissertation is organized into four chapters. Chapter 2 presents the aggregated patterns of life-cycle income and employment during the period 1985-2003 in Sweden, and provides readers with an overview of how the Swedish working life was changing over this time period. The econometric analysis in this chapter examines the life-cycle variation in intra- and inter-temporal substitution in labor supply, which appears very different among workers aged 60+ compared to their younger counterparts. This finding sets the stage for the remaining three chapters which investigate the labor market participation and exit behavior of older-aged workers in Sweden.

Chapter 2 is the first paper for Sweden analyzing the dynamic changes in life-cycle labor income overtime, thanks to the Swedish NTA time series data hosted by the Institute for Future Studies in Stockholm. Also, this chapter is the first macroeconomic study that estimates age differentials in labor supply elasticities. This estimation is an important contribution to the future application of overlapping generation models with computable general equilibrium (OLG-CGE), which was pioneered by Samuelson (1958) and Diamond (1965), and was put into practical

application by Auerbach and Kotlikoff (1987), Miles (1999), and Börsch-Supan (2003), among others. OLG-CGE traditionally assumes that the consumption and labor supply elasticity of substitution does not vary over the life-cycle. The validity of such an assumption, however, has seldom been addressed. Chapter 2 is, therefore, the first contribution to the literature which addresses this issue by examining the life-cycle dynamics of substitution patterns between labor supply and leisure.

As mentioned previously, the average age at labor market exit in Sweden increased about one month per year between 2000-2011 (Karlsson and Olsson, 2012). If such an increase is a result of the 1994 pension reform, one might expect that those born in 1938 or later should work more years than their older counterparts, as the reform actually introduced cohort differentials in benefit accounting, which created stronger incentives for the cohorts born after 1937 to work longer, compared to those earlier-born cohorts. Indeed, Figure 1.10 presents a trend reversal, whereby the effective retirement age declined between those born in 1928 and 1937, and gradually increased across those later-born. However, as shown in (1.10), these cohort trends may also arise from cohort differences in wages, population structure, preferences, in addition to that in pension benefits due to the reform. Therefore, Chapters 3, 4, and 5 are devoted to seeking a concrete explanation for this cohort trend reversal in mean retirement age.

Chapter 3 introduces a concept of required rate of replacement, which quantifies the pecuniary preference for retiring relative to working. The econometric model in this chapter is in the form of (1.7), which is specifically designed for estimating the required rate of replacement for retirement, a conceptualized measure revealing the pecuniary preference for retirement. The key question in this chapter is whether there is any difference in the required rate of replacement between the older and younger cohorts.

Chapter 4 estimates a retirement model that is in the form of (1.8). The model is estimated for each cohort, which allows for decomposing the overall cohort changes in retirement ages into changes in population composition and changes in preference. The central question is whether the observed changes in retirement age may be explained by variation in population characteristics. More explicitly, this chapter examines the relative contribution of population structural change ( $POP$  in (1.8)) and coefficient change ( $\Omega_n$  in (1.8)) to the cross-cohort variation in mean retirement age.

Chapter 5 estimates a retirement model that is more comprehensive than the two models in Chapter 3 and 4. It is comprehensive because it comprises all the elements in the retirement function as shown in (1.9). The merits of this model are twofold. First, the model is capable of distinguishing between the behavioral modification in response to pension reform and the preference changes that are independent of the reform, as the parameter set in this model is decomposed into pecuniary preference measured by  $\Omega_p$  in (1.9) and non-pecuniary preference captured by  $\Omega_n$  in (1.9). Second, this model allows for simulating a counter-factual retirement pattern by imposing the pension benefits  $OA$  for those affected by the pension reform equal to those who were unaffected. This essentially eliminates the treatment effect of pension reform on the benefit entitlements. The differences between the observed and counter-factual retirement ages, therefore, reflect the effects of pension reform. These effects are decomposed by sexes, educational levels, and occupations, which allows for addressing the question of how different socio-economic groups were affected by this pension reform.

## 8 Data

This dissertation starts with a macro analysis of the life-cycle labor supply behavior using the National Transfer Accounts Sweden 1985-2003 (NTA). The empirical analysis then moves down to the micro level and utilizes two types of individual-level data sets: the Survey of Health, Ageing, Retirement in Europe (SHARE), and the Swedish Interdisciplinary Panel (SIP). This section briefly introduces the data sources, their coverage, as well as the pros and cons of using them.

NTA is a comprehensive measure of the age distribution of economic activities. The age profiles reflect the life-cycle patterns of production and consumption. However, the construction of the NTA age profiles are derived from repeated cross-sections over time, therefore they shall be interpreted as in a quasi life-cycle framework. Since the main theme of this dissertation is about labor supply, only the age profiles of labor income in NTA are used for the analysis in Chapter 2, as they are the analogy of the market value of total labor supply. NTA labor income, by definition, includes workers' labor earnings, self-employed labor income, fringe benefits, and payroll tax contributed by employers. For the Swedish case, only the before-tax labor income for both employed and self-employed are used which are sourced from the Swedish income register data maintained by Statistics Sweden.

Many of the micro studies of retirement behavior are based on retirement surveys, such as the Health and Retirement Surveys (HRS) in the US, the Survey of Health, Ageing, Retirement in Europe (SHARE), the English Longitudinal Study of Ageing (ELSA). For example, Gruber and Wise (2004) presented a collection of micro studies on the effects of financial incentives on retirement outcomes using survey data. The European pattern of retirement has been extensively studied based on SHARE data (Börsch-Supan et al., 2009; Buchholz et al., 2013; Komp et al., 2010). One of the advantages of using survey data is that it provides information on the exact age of retirement. Therefore, defining the state of retirement becomes straightforward.

Another body of retirement literature, but to a much lesser extent, employs administrative register data to investigate the retirement patterns. These studies are mainly conducted across Nordic countries, thanks to rich information from the income registers. Recent studies relying on this type of data can be found in Johansson et al. (2014); Larsen and Pedersen (2005, 2013); Palme and Svensson (1999, 2004). However, defining the retirement state, or the retirement age/date, in register data is not as straightforward as in survey data. These studies usually defined the retirement state as when pension income exceeds a certain threshold, or conversely when labor income dips below some level, or a combination of both. Such an income-based definition of retirement might introduce a difference between the actual and “observed” retirement state. Thus, analyses of this type of data may potentially lead to different empirical evidence than what is found from survey information. For this, exploiting various type of data sources is needed to acquire a thorough understanding of retirement behavior.

Retirement studies in Sweden are dominated by exploiting register data, whereas little research has used survey data. This motivates Chapter 3 to conduct a study based on survey data, the Survey of Health, Ageing, Retirement in Europe (SHARE). It is important to stress that this is not an attempt to challenge the status quo findings in previous research based on register data, but rather to obtain complementary evidence for understanding retirement behavior. The analysis in Chapter 3 relies on the working life history collected in the third wave of SHARE. The data provides information on various life event episodes over the entire life course, e.g. period of education, job spell(s), unemployment, and retirement. All this information is collected by retrospective survey. I extracted the Swedish sub-sample of the data for the analysis, which amounts to 1893 individuals, 848 men and 1045 women.



The nature of the retrospective survey data, however, leads to several empirical concerns. First, the sample is small and its representativeness is uncertain, which prevented the findings from being generalized to the entire population. Second, a limited number of individuals also restrain the retirement model to only include pecuniary value of retirement, while non-pecuniary values, such as social, economic, and demographic characteristics are not included in the model. This may result in biased estimates of the parameters in the pecuniary value functions. Third, retrospectively collected information on life history may potentially introduce measurement errors, and, in turn, lead to misleading estimates. Hence, considering these potential drawbacks of using survey data, the last two chapters employ the register data covering the entire population in Sweden.

Chapter 4 and 5 explore the cohort trends in old-age employment and retirement using the Swedish Interdisciplinary Panel (SIP) that is administered by the Centre for Economic Demography at Lund University. SIP is constructed by merging individual-level information from several different administrative registers which are maintained at Statistics Sweden, including the income and taxation registers, the education register, the occupation register, the in- and out-patient registers, and the total population register. To this end, the merged database contains ample information on individual labor market outcomes, such as income and occupation, as well as socio-demographic and health characteristics. The database covers the entire population (roughly 12 million unique individuals) living in Sweden sometime during the period 1968-2013. The large samples size and detailed individual-level information provide an opportunity to uncover the social, economic, and demographic differences in labor supply trends, but also to examine the micro mechanisms driving these group-specific trends.

## 9 Methods

Chapter 2 is a macro study of life-cycle labor supply behavior in Sweden, which contains two parts. The first part of the study is a descriptive analysis of the time-varying age distribution of wage and employment. The repeated cross-sectional data over the period 1985-2003 are fitted by the Lee-Carter method (Lee and Carter, 1992), which captures the changing shape of life-cycle wages and labor supply, as well as age-specific responses to the overall trends of the two variables. The second part of Chapter 2 estimates an age-specific labor supply function, which is

theoretically consistent with the overlapping generation framework, based on the combined data source of time-varying age profiles of NTA labor income and other macroeconomic variables. The salient feature of the econometric analysis is that it allows for estimating an array of quasi life-cycle parameters which seldom exist in the traditional macroeconomic studies relying on national accounts.

The investigation of retirement behavior in Chapter 3 is based on survey data. The individual discrete choice between work and retirement over ages 60-70 is fitted with a multinomial logit model. The uniqueness of the estimation method in this chapter is that it applies Hierarchical Bayesian Estimation (HB) other than Maximum (Simulated) Likelihood, which are commonly used in previous literature. The utilization of HB is motivated by the concern that the small sample size in survey data might lead to the case of asymptotic properties not being fully exhibited. The realization of this problem is inspired by the assertion in Train (2009) that, unlike the classical statistics relying on the asymptotic assumption of the sampling distribution that is rarely fulfilled with insufficient sample size, Bayesian statistics estimates the posterior distribution of the parameters which contains the information for the entire sample regardless of size, and is therefore appropriate for small sample inference.

As stated earlier, Chapter 4 examines the potential impact of population compositional change on the cross-cohort variation in old-age employment. This analysis requires decomposition of the changes in the outcome variable into two components: changes in parameters and changes in covariates. The method used for the decomposition analysis is the Blinder-Oaxaca decomposition method. This method allows for quantifying the relative contribution of population structural change (the covariates) and behavioral change (the parameters associated with each covariates) to the overall cohort differences in the outcome. Or explicitly, this is to examine the relative importance between  $POP$  and  $\Omega_n$  in (1.8).

The purpose of the last chapter is to evaluate the effects of the 1994 Swedish pension reform on the length of working life. This causal inference is conducted in a counter-factual framework. An econometric retirement model is first estimated, which is then used for predicting the potential retirement patterns based on: 1) the pension benefits that are simulated by observed individual characteristics, and 2) the pension benefits that are simulated by eliminating the cohort differences in these benefits. These two types of simulated pension are essentially corresponding to the benefits level with and without the 1994 pension reform. Ultimately,

the differences between the two potential retirement patterns reflect the effects of pension reform. These effects are further decomposed by sexes, educational levels, and occupations, in order to address the question of how different socio-economic groups were affected by this pension reform.

## 10 Discussion and Conclusion

Chapter 2 conducts a macro econometric analysis of the labor supply responses to wage changes using the Swedish National Transfer Accounts 1985-2003. The estimated elasticity in the aggregate model (i.e. a model for all age groups combined) is very close to the empirical benchmark, such as the elasticity estimated in Alogoskoufis (1987) and Lucas and Rapping (1969). However, the age-specific estimates reveal considerable variation in the short-run labor supply elasticity and the relative magnitude of inter- and intra-temporal elasticity. This finding first suggests that labor supply elasticities estimated in traditional macroeconomic studies only reflect the labor supply behavior in a single representative household framework, but certainly not in an overlapping generation setting where agents differ by age. Secondly, these results have important implications for the future application of overlapping generation models with computable general equilibrium. That is, an array of life-cycle parameters are necessary for calibrating such a model for the generational economy.

Moreover, the results in Chapter 2 show that labor supply is positively related with wage (a substitution effect dominates) over most of the working life. This effect, however, no longer holds when workers turn age 60 and older, as it then becomes outweighed by income effects. Such income effects at higher ages are likely due to the ignorance of outside options, namely retirement options in the econometric model. This motivates the remaining chapters to take a closer look at working life at older ages. In particular, they investigate the underlying mechanisms driving the recent changes in old-age labor supply, such as the cohort trends in the effective retirement age shown in Figure 1.10.

Using the survey data, Chapter 3 estimates a retirement model containing a key preference parameter, the required rate of replacement, which quantifies the pecuniary preference for retiring relative to working. The estimated pecuniary preference is comparable with the findings in Stock and Wise (1990). The econometric analysis is further extended to examine the difference in pecuniary preferences

across two unique cohorts, the results of which uncover little difference, meaning that the younger cohort required the same level of pension relative to their work income as did the older cohort in order to retire. This finding suggests that the cohort trend in the effective retirement age shown in Figure 1.10 might not have been driven by the cohort difference in pecuniary preferences. As guided by the theoretical framework presented in (1.10), other factors that may have driven the cross-cohort variation in retirement age could be changing labor income, pension entitlements, and/or population structure. These factors are, therefore, examined in the last two chapters of this dissertation based on population-wide register data.

Chapter 4 relates the cohort trend in retirement age to the cross-cohort variation in population composition. The argument is that if highly educated and skilled, and healthy workers are more likely to work longer (as suggested in many previous studies, such as Börsch-Supan et al. (2009), Buchholz et al. (2013), Glans (2008), Klevmarken (2010), Komp et al. (2010), Larsen and Pedersen (2013), and Stenberg and Westerlund (2013)), then the cohort trend increase in the effective retirement age may have risen due to changes in the population structure, such that later-born cohorts might be increasingly healthier, better educated and skilled. Using Blinder-Oaxaca decomposition analysis, this chapter finds that about one-fourth of the cohort variation in the length of working life for women was due to changing population composition, mainly an increasingly educated female labor force. However, for men, the cohort trend of working longer seemed unrelated to any structural changes in the population, which prompts the final chapter to address the question of whether the prolonged working life, particularly for men, was associated with variation in old-age pension.

Indeed, Chapter 5 finds that the reduced pension benefits for men born in 1938 and later, due to the 1994 public pension reform, played an important role in prolonging their working lives. And the effects of the benefit reduction were large and nearly identical across all educational and occupational groups. For women however, although the cohort trend of working longer was similar to that for men, it was only mildly explained by the pension reform. Taking the 1944 cohort as an example, the mean retirement age was increased by 2.4 months for men solely due to the pension reform, whereas it increased merely 0.6 months for women.

Combining the empirical results from Chapter 4 and 5, a more comprehensive conclusion can be drawn as follows. While a common trend of working longer was observed across individuals of different sexes, health status, occupations, and edu-

cational levels, the underlying mechanisms driving these developments appeared to differ between men and women. The results of this work reveal a strong effect of the pension reform on men's prolongation of working life, but not on women's, whose recent increase in retirement age was due partly to the fact that women, on average, became increasingly educated and skilled. These gender-specific mechanisms challenge the institutional explanation of the recent trend in extending working life in Sweden by Glans (2008); Johansson et al. (2014); Karlsson and Olsson (2012); Karlström et al. (2008). More rigorous empirical studies are, therefore, needed to examine why working life is being prolonged, particularly for the Swedish female labor force. While the geographical scope of this dissertation is limited to one country, future research on this topic would benefit from analyzing the trends in working life extension with an international perspective, as the trend reversal in retirement ages across many OECD may also be propelled by unique mechanisms across different social, economic, and demographic groups.

Finally, the empirical results presented in this dissertation highlight the importance of conducting more individual-level research to better understand why we are working longer. Such an understanding is crucial for assessing the welfare consequences of population ageing, as the micro mechanisms driving the changing labor force participation may have myriad implications concerning the future economic support for ageing societies.

## References

- Alogoskoufis, G. S. (1987, Oct). On Intertemporal Substitution and Aggregate Labor Supply. *Journal of Political Economy* 95(5), 938–960.
- Auerbach, A. and L. Kotlikoff (1987). *Dynamic Fiscal Policy*. Cambridge University Press.
- Barro, R. J. (1974). Are Government Bonds Net Wealth? *Journal of Political Economy* 82(6), 1095–1117.
- Bengtsson, T. (2010). *Population Ageing - A Threat to the Welfare State? The Case of Sweden*. Springer-Verlag Berlin Heidelberg.
- Bengtsson, T. and K. Scott (2011). Population Ageing and the Future of the Swedish Welfare State. *Population and Development Review* 37, Supplement.

- Berkovec, J. and S. Stern (1991). Job Exit Behavior of Older Men. *Econometrica* 59(1), 189–210.
- Bloom, D. E. and D. Canning (2009). Fertility, Female Labor Force Participation, and the Demographic Dividend. *Journal of Economic Growth* 14(2), 79–101.
- Börsch-Supan, A. (2003). Labor Market Effects of Population Aging. *Labour Special Issue*, 5–44.
- Börsch-Supan, A., A. Brugiavini, and E. Croda (2009). The Role of Institutions and Health in European Patterns of Work and Retirement. *Journal of European Social Policy* 19(4), 341–358.
- Buchholz, S., A. Rinklake, and H. P. Blossfeld (2013). Reversing Early Retirement in Germany A Longitudinal Analysis of the Effects of Recent Pension Reforms on the Timing of the Transition to Retirement and on Pension Incomes. *Comparative Population Studies* 38(4).
- Coale, A. J. (1957). How the Age Distribution of A Human Population Is Determined. *Cold Spring Harbor Symposia on Quantitative Biology* 22, 83–89.
- Diamond, P. (1965). National Debt in a Neoclassical Growth Model. *The American Economic Review*.
- Floud, R., R. W. Fogel, B. Harris, and S. C. Hong (2011). *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700*. Cambridge: Cambridge University Press.
- Fogel, R. W. (2004a). Technophysio Evolution and the Measurement of Economic Growth. *Journal of Evolutionary Economics* 14(2), 217–221.
- Fogel, R. W. (2004b). *The Escape from Hunger and Premature Death, 1700–2100: Europe, America, and the Third World*. New York: Cambridge University Press.
- Fogel, R. W. and D. L. Costa (1997). A Theory of Technophysio Evolution, With Some Implications for Forecasting Population, Health Care Costs, and Pension Costs. *Demography* 34(1), pp. 49–66.
- Glans, E. (2008, November). Retirement Patterns during the Swedish Pension Reform. Working Paper Series 2008:9, Uppsala University, Department of Economics.

- Gruber, J. and D. Wise (1999). *Social Security and Retirement around the World*. Chicago, IL: The University of Chicago Press.
- Gruber, J. and D. Wise (2004). *Social Security and Retirement around the World: Micro Estimation of Early Retirement Incentives*. Chicago, IL: The University of Chicago Press.
- Hagen, J. (2013, May). A History of the Swedish Pension System. Working Paper Series, Center for Fiscal Studies 2013:7, Uppsala University, Department of Economics.
- Hallberg, D., T. Lindh, G. Öberg, and C. Thulstrup (2011). Intergenerational Redistribution in Sweden's Public and Private Sectors. In R. Lee and A. Mason (Eds.), *Population Aging and The Generational Economy, A Global Perspective*. Edward Elgar Publishing Limited.
- Harper, S. (2014). Economic and Social Implications of Aging Societies. *Science* 346(6209), 587–591.
- Heyma, A. (2004). A Structural Dynamic Analysis of Retirement Behaviour in the Netherlands. *Journal of Applied Econometrics* 19(6), 739–759.
- Jappelli, T. and F. Modigliani (2005). The Age-Saving Profile and the Life-Cycle Hypothesis. In F. Franco (Ed.), *The Collected Papers of Franco Modigliani*, Volume 6. MIT Press.
- Johansson, P., L. Laun, and M. Palme (2014, May). Pathways to Retirement and the Role of Financial Incentives in Sweden. NBER Working Papers 20123, National Bureau of Economic Research.
- Karlsson, H. and H. Olsson (2012). Medelpensioneringsalder och Uttradesalder 2011.
- Karlström, A., M. Palme, and S. Ingemar (2008). The Employment Effect of Stricter Rules for Eligibility for DI: Evidence from A Natural Experiment in Sweden. *Journal of Public Economics* 92, 2071–2082.
- Karlström, A., M. Palme, and I. Svensson (2004). A Dynamic Programming Approach to Model the Retirement Behaviour of Blue-Collar Workers in Sweden. *Journal of Applied Econometrics* 19(6), 795–807.

- Klevmarken, A. (2010). Vereforms efter 65 års ålder? En statistisk analys. Report från sociala rådet, Statens Offentliga Utredningar.
- Komp, K., T. Tilburg, and M. B. Groenou (2010). Paid Work between Age 60 and 70 Years in Europe: A Matter of Socio-economic Status? *International Journal of Ageing and Later Life*.
- Konberg, B., E. Palmer, and A. Sunden (2006). The NDC Reform in Sweden: the 1994 Legislation to the Present. In R. Holzmann and E. Palmer (Eds.), *Pension Reform: Issues and Prospects for Non-financial Defined Contribution (NDC) Schemes*. Washington D.C.: The World Bank.
- Larsen, M. and P. Pedersen (2013). To Work, to Retire, or Both? Labor Market Activity after 60. *IZA Journal of European Labor Studies* 2(1).
- Larsen, M. and P. J. Pedersen (2005, April). Pathways to Early Retirement in Denmark, 1984-2000. IZA Discussion Papers 1575, Institute for the Study of Labor (IZA).
- Laun, T. and J. Wallenius (2015, July). A Life Cycle Model of Health and Retirement: the Case of Swedish Pension Reform. *Journal of Public Economics* 127, 127–136.
- Lee, R. and L. Carter (1992). Modeling and Forecasting U.S. Mortality. *Journal of the American Statistical Association* 87(419), 659–671.
- Lee, R. and R. D. Edwards (2001). The Fiscal Impact of Population Change. In *Seismic Shifts: The Economic Impact of Demographic Change*, Number 46, Boston, pp. 190–219. Federal Reserve Bank of Boston conference Series.
- Lee, R., D. Gretchen, and T. Miller (2011). The Changing Shape of the Economic Life-cycle in the United States, 1960 to 2003. In R. Lee and A. Mason (Eds.), *Population Aging and The Generational Economy, A Global Perspective*, Chapter 15, pp. 313–326. Edward Elgar Publishing Limited.
- Lee, R. and A. Mason (2011). *Population Aging and the Generational Economy: A Global Perspective*. Edward Elgars.
- Lee, R. D. (1994). The Formal Demography of Population Ageing, Transfer, and the Economic Life Cycle. In L. G. Martin and S. H. Preston (Eds.), *Demography of Ageing*, pp. 8–49. Washington, DC: National Academy Press.



- Lee, S. and N. Ogawa (2011). Labor Income over the Lifecycle. In R. Lee and A. Mason (Eds.), *Population Aging and The Generational Economy, A Global Perspective*, Chapter 5, pp. 109–135. Edward Elgar Publishing Limited.
- Livi-Bacci, M. (2000). The End of A Cycle. In M. Livi-Bacci (Ed.), *The Population of Europe*. Oxford: Blackwell Publishers.
- Lucas, R. and L. Rapping (1969). Real Wages, Employment, and Inflation. *Journal of Political Economy* 77(5), 721–754.
- Lumsdaine, R. L., J. H. Stock, and D. A. Wise (1992). Three Models of Retirement: Computational Complexity versus Predictive Validity. In D. A. Wise (Ed.), *Topics in the Economics of Aging*. University of Chicago Press.
- Mason, A. (2005). Demographic Transition and Demographic Dividends in Developed and Developing Countries. In *United Nations Expert Group Meeting on Social and Economic Implications of Changing Population Age Structures, Mexico City*. United Nations.
- Mason, A. and R. Lee (2007). Transfers, Capital, and Consumption over the Demographic Transition. In R. Clark, A. Mason, and N. Ogawa (Eds.), *Population Aging, Intergenerational Transfers and the Macroeconomy*, pp. 128–162. Elgar Press.
- Mason, A. and R. Lee (2011). Population Aging and the Generational Economy: Key Findings. In R. Lee and A. Mason (Eds.), *Population Aging and The Generational Economy, A Global Perspective*, Chapter 1, pp. 3–31. Edward Elgar Publishing Limited.
- Miles, D. (1999, Jan). Modelling the Impact of Demographic Change upon the Economy. *The Economic Journal* 109(452), 1–36.
- OECD (2006, February). *Live Longer, Work Longer*. OECD.
- OECD (2013). Pensions at A Glance 2013: OECD and G20 Indicators. *OECD Publishing*.
- Oppen, J. and J. Vaupel (2002). Broken Limits to Life Expectancy. *Science*, 1029–1031.

- Palme, M. and I. Svensson (2004). Income Security Programs and Retirement in Sweden. In *Social Security Programs and Retirement around the World: Micro-Estimation*, NBER Chapters, pp. 579–642. National Bureau of Economic Research, Inc.
- Palme, M. and I. Svensson (1999). Social Security, Occupational Pensions, and Retirement in Sweden. In J. Gruber and D. A. Wise (Eds.), *Social Security and Retirement around the World*. University of Chicago Press.
- Palmer, E. (2000). The Swedish Pension Reform Model : Framework and Issues. Discussion Papers no. 23086, The World Bank.
- Preston, S. H., P. Heuveline, and M. Guillot (2001). *Demography: Measuring and Modeling Population Processes*. Blackwell Publishing Ltd.
- Preston, S. H., C. Himes, and M. Eggers (1989, Nov). Demographic Conditions Responsible for Population Ageing. *Demography* 26(4), 691–704.
- Prskawetz, A. and J. Sambt (2014). Economic Support Ratios and the Demographic Dividend in Europe. *Demographic Research* 30(34), 963–1010.
- Samuelson, P. (1958). An Exact Consumption Loan Model of Interest with or without the Social Contrivance of Money. *Journal of Political Economy*.
- Samuelson, P. A. (1975). The Optimum Growth Rate of A Population. *International Economic Review* 16(3), 531–538.
- Settergren, O. (2001). Two Thousand Five Hundred Words on the Swedish Pension Reform. Working Papers no. 2001:1, The National Social Insurance Board.
- Skirbekk, V. (2003). *Age and Individual Productivity: A Literature Survey*. MPIDR.
- Stenberg, A. and O. Westerlund (2013). Education and Retirement: Does University Education at Mid-Age Extend Working Life? *IZA Journal of European Labor Studies* 2(1).
- Stock, J. H. and D. A. Wise (1990). Pensions, the Option Value of Work, and Retirement. *Econometrica* 58(5), 1151–80.
- Sunden, A. (2006). How Much Do People Need to Know about Their Pensions and What Do They Know? In R. Holzmann and E. Palmer (Eds.), *Pension Reform: Issues and Prospects for Non-financial Defined Contribution (NDC) Schemes*. Washington D.C.: The World Bank.

- Train, K. E. (2009). *Discrete Choice Methods with Simulation*. Cambridge University Press.
- Tung, A. (2011). Consumption Over the Lifecycle: An International Comparison. In R. Lee and A. Mason (Eds.), *Population Aging and The Generational Economy, A Global Perspective*, Chapter 6, pp. 136–160. Edward Elgar Publishing Limited.
- United Nations (2013). *National Transfer Accounts Manual: Measuring and Analysing the Generational Economy*. New York: United Nations.
- United Nations (2015). *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables*. New York: United Nations.



## Chapter II





## Chapter 2

# Real Wage and Labor Supply in A Quasi Life-cycle Framework: A Macro Compression by Swedish National Transfer Accounts (1985-2003)

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# Abstract

This paper examines the life-cycle dynamics of real wages and labor supply in Sweden. The descriptive results lend support to the inter-temporal substitution hypothesis (ISH), as the age patterns of real wages and labor supply are both hump-shaped. However, the age-wage profiles increasingly shift towards older ages over time, whereas the age-employment profiles do not. This leads to an accentuated difference-in-differences of the two variables from prime working age through retirement, which casts doubt on the explanatory power of ISH for the life-cycle labor supply. Econometric analysis shows that the intra-temporal elasticity outweighs the inter-temporal elasticity of substitution, therefore giving little support for ISH. The estimated labor supply elasticity also varies considerably across age groups. This suggests that an array of age-specific parameters is needed in calibrating the Overlapping Generation Model (OLG).

**Keywords:** Population ageing, Life-cycle labor Supply, Inter-temporal substitution hypothesis, Overlapping generation model

## 1 Introduction

At the frontier of the best-practice life expectancy, Sweden is likely to reach a life expectancy at birth of one hundred in about six decades (Oppen and Vaupel, 2002). Coupled with the low fertility of recent decades, the share of the age 65+ population is expected to grow. Holding the mean age at retirement constant, this process implies the per worker cost of providing a given age-vector of per capita benefits will increase (Lee and Edwards, 2001), encompassing costs for health care, elderly care, and all other types of old-age social security programs. One might argue that cutting benefits could be one of the options for balancing the public budget; however, this simply shifts responsibility from the public to the private sector and not in any way addressing the consequences of population ageing. In fact it is possible that overall economic efficiency deteriorates if some welfare services are pushed into home production and forces decreased labor market participation.

Alternatively, if such expenditure is financed by national debt, it tends to be paid by future generations, thus giving rise to inter-generational equity issue. Unless



the Ricardian Equivalence Proposition holds,<sup>1</sup> public debt would possibly crowd out private capital, erode productive investment, and potentially depress the output. In an open economy, the crowding out effect may be attenuated by attracting foreign capital (Modigliani, 1986). This might possibly mitigate the loss of domestic capital and maintain the level of investment. However, population ageing is becoming a global phenomenon, whether the inflow of foreign capital can sufficiently offset the crowding out of private capital remains uncertain. Additionally, even though external debt can be issued, it still needs to be repaid by the future generations, thus the generational equity issue remains.

The costs of the elderly in Sweden are largely covered by tax revenues. Therefore, to finance such growing costs require either expanding the tax base or increasing the tax rate. Given the taxation level in Sweden that has already gone beyond the international average, broadening the tax base seems a more reasonable solution. Demographic measures might be useful in enlarging the tax base; however, this may introduce additional obstacles. For instance, poor integration of immigrant workers to the Swedish labor market might induce additional burdens on the society. Rising fertility, on the other hand, would take at least 25-30 years before exerting positive effect on the size of the working population (Bengtsson and Scott, 2011). Hence, a more realistic alternative seems to be to increase the labor supply among those who are “able to work”.

Recent trends toward better health in the age of 60s and 70s in Sweden present another potential: prolonging working life. However, during the first decade of this century, labor force participation for 65+ remained constantly low at around 10 percent in Sweden. Youth labor force participation, on the other hand, exhibits a downward trend, which is particularly profound during the great recession after the year of 2008.<sup>2</sup> Such patterns imply that policy measures that encourage early entry and late exit to the labor market are needed for the expansion of the tax base. This is perhaps also the most effective way, because both the youth and the elderly form a large share of the exploitable human resource. More importantly, if they remain outside of the workforce, an additional burden would emerge leading to multiplicative stress on the welfare state.

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<sup>1</sup>Ricardian Equivalence holds if the bequest and gift motives generate private flows sufficient to offset changes in the level of government deficit, then there is no impact on short-run and long-run equilibrium (Barro, 1974).

<sup>2</sup>Data source used for discussion here refers to Labor Force Statistics in OECD Countries. Detailed information on compiling statistics from different countries can be found at: [www.oecd.org/els/employmentpoliciesanddata/LFSNOTES](http://www.oecd.org/els/employmentpoliciesanddata/LFSNOTES).

To assess the long-term impact of population ageing, one has to consider various scenarios of labor supply. A thorough understanding of the labor supply behavior is a *sine qua non* for formulating meaningful scenarios so as to evaluate viable solutions. For this, the present study has significant policy relevance as it contributes to the understanding of the behavior of labor supply.

Since the introduction of the inter-temporal substitution hypothesis (hereafter ISH) by Lucas and Rapping (1969), labor supply has attracted enormous attention in macroeconomics. ISH argues that the labor supply and wage should be positively correlated over the life-cycle. This is because the life-cycle wage profile is assumed to be foreseeable for individuals, known as “evolutionary wage growth”. This wage pattern can only generate substitution effects on labor supply given the assumption that rational agents will concentrate labor supply over the ages with higher work compensation and enjoy more leisure when wages are low (Macurdy, 1981).

It has eluded economists to agree upon the magnitude of this elasticity. Labor economists typically obtain small estimates at the individual level, while macro-economists provide mixed evidence. Mankiw et al. (1985) found no statistical evidence supporting ISH, while Alogoskoufis (1987) obtained higher estimates of intertemporal real wage elasticity than others. To this point Lucas and Rapping (1969) have obtained the largest estimate on the short-run labor supply elasticity with respect to wage, 1.4. They claim this finding as the supporting evidence for the Keynesian-type assumption of a elastic short-run supply schedule. This paper adds some new insights to this issue, as well as other so called “Puzzles”.

There has been a long tradition in introducing age into macro economic models. The overlapping generational model with computable general equilibrium (OLG-CGE) is one of such frameworks pioneered by Samuelson (1958) and Diamond (1965), and pursued by a number of followers in various applications (e.g. Auerbach and Kotlikoff (1987), Miles (1999), and Börsch-Supan (2003)).

All of these models assume that the elasticity of substitution does not vary over the life-cycle. The parameters for calibrating these models are mostly taken from aggregate time-series analysis without taking into account the age-differentials. This leads to inconsistencies between the setting where empirical evidence is obtained and that to which estimated elasticities are applied.

Aggregate estimates of time-series data, in fact, correspond to a model of a single

infinitely lived representative agent. This differs from the Overlapping Generation (OLG) environment, where multiple agents live with finite lives and coexist with different age groups at each point in time. Such estimated elasticity does not necessarily reflect the actual behavior of the agents at different stages of the life-cycle, which could potentially eliminate the disproportional age-specific responses to macro-economic change.

For this reason, I use the National Transfer Accounts (NTA) for Sweden with time-varying age profiles of economic activity for the period 1985-2003 to estimate a life-cycle labor supply function. The estimation is theoretically consistent with the overlapping generation framework, allowing me to envisage a more realistic life-cycle model with age-separable elasticities of labor supply with respect to wage. This can serve as a new basis for future application of OLG models.

The remainder of the paper is organized as following. First, I give some theoretical consideration of the life-cycle real wage and labor supply. Next, various data sources and empirical models are introduced. The results are then reported and discussed in the following section. Finally, some key findings are summarized in the conclusion.

## **2 A General Theory of Real Wage and Labor Supply - A Life-cycle Perspective**

### **2.1 Age-Wage Differential**

Wage differentials between young and old workers might be a result of wage-productivity discrepancy, in which young workers are underpaid and old workers are overpaid relative to their productivity (Skirbekk, 2003). A few theories attempt to explain the existence of wage-productivity discrepancy and age-wage differentials.

The efficiency wage hypothesis argues that firms will be unconstrained by labor market conditions in pursuing its optimal policy on recruiting, as long as labor supply exceeds demand, and the real wage offers are higher than the reservation wages (Yellen, 1984). One extension of this hypothesis seeks to explain why firms are willing to pay a wage rate above market clearing, namely the shirking model. It applies to the condition that piece rate is an inaccurate measure of productivity,

and that over pay with respect to productivity provides incentives for workers not to shirk (Calvo, 1979).

Additionally, one might wonder why firms prefer to pay workers less when they are young and more when they are old with respect to marginal product. This can be argued as a result of the nature of the optimal wage profile. Such contracted pay schedule would lead to Pareto Efficiency with mandatory retirement (Lazear, 1981). Time spent in the labor market might also affect the wage distribution across age groups. Senior workers earn more on average, even if perceived productivity is held constant. This is because they have had more time to bid up their wage, and their ability can be more precisely assessed (Harris and Bengt, 1982).

Finally, the age distribution of labor earnings might also be influenced by trade unions. If unions attach greater weight to the wishes of old workers than young workers, and wages and employment are determined by efficient collective bargaining, the wages of older workers will always be higher than the younger ones regardless of productivity and labor supply (Pissarides, 1989).

The time varying age-wage patterns have been rarely examined in the current empirical literature, partly because yearly age-profiles of wage are often unavailable. To the best of my knowledge, the only systematic investigation of the annual variation in the shape of the life-cycle earning profiles being conducted is for the U.S. using Current Population Survey 1962-2003. One of the major findings from that study is that there was a consistent upward trend for the earnings of older men, relative to the younger men, which is attributable to the fact that younger workers no longer possess educational advantage over older workers (Lee et al., 2011).

In short, theoretical literature generally predicts that workers at younger ages tend to be underpaid relative to at older ages. Hence, one of the purposes for the present study is to verify whether the age-profile of labor income is in line with theoretical predictions. Furthermore, I also attempt to examine whether there is an upward trend for the earnings of older men relative to the younger man overtime in Sweden.

## **2.2 The Substitution and Income Effects on Labor Supply**

With the standard assumption of leisure being a normal good, an increase in real wage would have two possible impacts on labor supply, i.e. the substitution and

income effects. Based on the two opposite effects, micro-economists envisage the possible shapes of the individual labor supply curve, i.e. a strictly positive supply curve and a backward-bending supply curve. The former suggests the substitution effects consistently outweigh the income effects. On the contrary, the latter implies that the substitution effects dominate to a certain point, where both wage and working hours reach a relatively high level, and then income effects kick in and outweigh substitution effects. Accordingly, any further increase after a threshold of real wage and hours worked would induce individuals to reduce labor supply in order to consume more leisure.

The two competing theoretical predictions lead to an important question: which curve better depicts the individual labor supply. Empirical evidence, thus far, provides a mixture of these two. Although cross-sectional evidence that mainly measures the short-run labor supply curve suggests that the substitution effects dominate, at least for married women (Cain, 1966; Mincer, 1962), secular trends consistently lend support for the backward-bending supply curve, particularly in the long-run.

### 2.3 The Inter-Temporal Substitution Hypothesis

It is important to note that the former discussion on substitution and income effects has been restricted to the static analyses. For a comprehensive life-cycle analysis of labor supply, it is necessary to distinguish between the intra-temporal effect and the inter-temporal effect; specifically to disentangle the labor supply response to an unanticipated wage shift from an anticipated evolutionary wage growth.<sup>3</sup>

There are substantial differences between the two sorts of responses. The unanticipated wage shift can yield not only substitution effects, but also income effects, as just discussed in the one-period analysis. The evolutionary wage growth, on the other hand, can only generate substitution effects. This is because, given that the life-cycle wage profile is foreseeable, rational agents would concentrate their labor supply over the ages with the highest wages, whereas demand more leisure when wages are low (Macurdy, 1981). Such an assumption implies that the labor supply and wage rate should be positively correlated over the life-cycle, i.e. inter-temporal substitution hypothesis (hereafter, ISH).

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<sup>3</sup>A fuller discussion on this distinction is given in Macurdy (1981).

Empirical literature, however, provides inconsistent evidence. Mankiw et al. (1985) found no statistical evidence supporting ISH using aggregate U.S. data. Alogoskoufis (1987), on the other hand, found substantially higher estimates of intertemporal real wage and interest rate elasticities than others.

Such inconsistency is possibly due to the measurement of labor supply. Mankiw et al. (1985) used the aggregate man-hours, which is criticized as the least important component by Heckman (1993). Alogoskoufis (1987) rather found strong inter-temporal elasticity when using number of employees and employment rates, yet weak estimates when using total employee hours. This is not surprising, as hours are not as flexible as theoretically assumed in daily working life. The pattern of hours worked over the life-cycle typically appear sticky, at least for male workers over the prime working ages. As a result, the labor supply (measured by worked hours) responsiveness to wage changes tends to be weak and insignificant. At an aggregate level, most of the variations in total manhours comes from the employment variation, not hours per head (Coleman, 1984). In addition, Heckman (1993) asserted that the strongest empirical effects of wages and non-labor income on labor supply are at the extensive margin, where the elasticity is unequivocally not zero.

## **2.4 Labor Supply Elasticity in An Overlapping Generation Setting**

Not only are labor supply elasticities important for understanding individual behavior, but also for addressing broader policy issues. For instance, to evaluate the financial stability of a pension systems or experiment with welfare consequences of potential reforms, one common practice is to calibrate the estimated elasticities into an overlapping generation model with computable general equilibrium (OLG-CGE), e.g. Auerbach and Kotlikoff (1987); Börsch-Supan (2003); Miles (1999), etc. Two major issues arise when conducting this type of analysis.

The first issue is the decision upon what parameter values to use, as the estimated elasticities vary with respect to different sources and little consensus has been reached in terms of their magnitude and representativeness. Prescott and Wallenius (2011) summarized that aggregate elasticities are typically found larger than individual elasticities. This facilitates the argument that one should not estimate parameters in one setting and apply them to another. In this regard, OLG-CGE, as an abstracted macro model, should be calibrated by elasticities estimated at ag-

gregate level.

This leads to the second issue that aggregate estimates of time-series data, in fact, correspond to a single agent model with infinite life. This is not necessarily equivalent to the OLG setting, where multiple agents at different ages co-live at each point in time with a finite life span. Such estimated elasticities could potentially eliminate the disproportionate impact of macro-economic change on various agents who are co-existing in the stylized environment at a given point in time. For example, empirical evidence, discussed earlier, shows that youth were hit particularly hard during the recent recession (OECD, 2011). Such unevenly distributed responses to business cycles cannot be reflected in OLG simulations if one assumes elasticities are constant over ages and calibrate on the basis of estimates from aggregate data in the national accounts.

To the best of my knowledge, none of the OLG models, so far, have incorporated age-specific parameters governing inter- and intra-temporal decisions in the calibration. Furthermore, there have been very few macro-economic studies empirically estimating age-specific elasticities.

Fair (1971) examined the relation between wage, money illusion, and labor force participation by using quarterly data for the U.S. 1956-1970. The variables are age- and gender- specific. The study did not find any consistent labor supply response to wage by different demographic groups, nor were the wage and money effects substantively distinguishable. One drawback of Fair's analysis is the lack of theoretical foundation, both in terms of variables chosen, model specification, and the length of distributed lags.

Accordingly, it is necessary to estimate an empirical model that is consistent with theory as well as applicable to the environment that theory assumes. In the case of estimating a labor supply function that is compatible with the OLG model, one must emphasize the age differences in estimated elasticities, and specify the model in line with the theoretical framework. In other words, it is to explicitly address the question whether workers at different stages of the life-cycle could have different inter-temporal and intra-temporal response to wage change.

### 3 A Macro Life-cycle Model

A new classical model of the dynamic household's labor supply and firm's marginal productivity condition for labor was first introduced by Lucas and Rapping (hence after, L-R model), and applied to the U.S. labor market. Prior to that, labor supply decisions were regarded as virtually irrelevant for this level of analysis since aggregate labor supply was not seen as determined by factors driving individual labor supply (Prescott and Wallenius, 2011).

The next section gives a brief presentation of a multi-period life-cycle model. Although a more realistic model should comprise multi-sectors, households, firms, government, and, perhaps, banking, I shall limit my theoretical consideration to household and firm sectors only. The main purpose here is to give a basis for deriving an empirically testable labor supply function for the current analysis. The model presented here shares certain characteristics as L-R model, yet differs in some ways.

#### 3.1 Household Behavior

In an overlapping generation setting, each representative household lives up to a certain date  $T$ . In each period, the household that has reached  $T$  dies out and a newborn enters. The households derive their utility from consumption and leisure, which can be traded not only within, but also across periods.

For simplicity, I first consider the household as a single representative agent in the economy which does not correspond to the multi-generational agents in the OLG setting. In other words, the household behavior presented here is only comparable with aggregate time-series analyses, e.g. Lucas and Rapping (1969) and Alogoskoufis (1987). The purpose of simplifying the model in this way is to derive the theoretical predictions of labor supply responses to wage. A more general model for multi-generational agents will be presented in the empirical estimation. For the single representative agent in the economy, the implicit lifetime utility function may be expressed as,

$$U = \frac{1}{1 - 1/\gamma} \sum_{t=0}^T \frac{1}{(1 + \delta)^t} u_t(c_t, l_t)^{1-1/\gamma} \quad (2.1)$$



where,  $t$  is age/time,  $\delta$  is the rate of time preference,  $\gamma$  is the inter-temporal elasticity of substitution, and  $c$  and  $l$  denote consumption and leisure, respectively.

Assuming there is no income and payroll tax, nor any kind of social benefits, the household budget constraint is merely a function of current and future discounted assets and labor income with the requirement that lifetime consumption does not exceed the earnings at the present value. The budget constraint can, therefore, be written as,

$$a_t + \sum_{t=0}^T \prod_{t=0}^T (1 + r_t)^{-1} [a_t r_t + w_t(1 - l_t)] \geq \sum_{t=0}^T \prod_{t=0}^T (1 + r_t)^{-1} c_t \quad (2.2)$$

where,  $c$ ,  $l$ ,  $r$  and  $a$  are consumption, leisure, interest rate and assets, respectively.  $w$  is the per worker annual wage.

It is important to note that the value of  $l$  is assumed to be  $l \in [0, 1]$  and reflects the age- or time-varying fraction of total labor endowment allocated into leisure. Accordingly,  $1 - l$  is the fraction of total labor endowment devoted to work. In general, for an unemployed,  $l = 1$ , whereas for a full time worker,  $l = 0$ , and any value between 0 and 1 refers to the intensive margin of labor supply. As argued by Alogoskoufis (1987), such a theoretical model is not applicable to modelling the extensive margin. To conduct the analysis using aggregate data, one has to use a continuous variable that is in line with the work-leisure choice by a single representative agent. This issue will be further discussed later.

The preferences in (2.1) are further restricted by assuming that the implicit utility function is time-separable and in the nested constant elasticity of substitution form. This gives the annual utility function,

$$u_t(c_t, l_t) = (c_t^{1-1/\rho} + \alpha l_t^{1-1/\rho})^{\frac{1}{1-1/\rho}} \quad (2.3)$$

where,  $\alpha$  and  $\rho$  are the parameters of intensity for leisure and intra-temporal elasticity, respectively.

Each household maximizes its lifetime utility (2.1) subject to a lifetime budget constraint (2.2). At each age, household solves a dynamic optimization problem, and derive their consumption and leisure. The economy is closed (i.e. no international trade, capital flows and migration) and both the labor market and capital market are perfectly competitive. In addition, the household is assumed to have no bequest motive. Substituting (2.3) into (2.1), the Hamiltonian for each representative

household may be expressed as,

$$H_t = \frac{1}{(1 + \delta)^t} \frac{1}{1 - 1/\gamma} (c_t^{1-1/\rho} + \alpha l_t^{1-1/\rho})^{\frac{1-1/\gamma}{1-1/\rho}} + \lambda_t [a_t r_t + w_t(1 - l_t) - c_t] \quad (2.4)$$

where,  $\delta, \alpha, \gamma, \rho$  are the parameters of time preference, intensity for leisure, inter-temporal elasticity and intra-temporal elasticity, respectively. Subscripts  $t$  denote age/time. Let  $c, l, r$  and  $a$  be consumption, leisure, interest rate and assets, respectively.  $\lambda$  is the costate variable that can be interpreted as the marginal value of a unit change in the budget constraint.  $w$  is the annual per worker wage rate.

Maximizing (2.4) with respect to  $c_t$  and  $l_t$ , respectively, yields the following two first-order conditions,

$$\lambda_t = (1 + \delta)^t (c_t^{1-1/\rho} + \alpha l_t^{1-1/\rho})^{\frac{1/\rho-1/\gamma}{1-1/\rho}} c_t^{-1/\rho} \quad (2.5)$$

$$\lambda_t w_t = (1 + \delta)^t (c_t^{1-1/\rho} + \alpha l_t^{1-1/\rho})^{\frac{1/\rho-1/\gamma}{1-1/\rho}} \alpha l_t^{-1/\rho} \quad (2.6)$$

Combining the two first-order conditions yields (2.7), an expression for the intra-temporal effect of wage change on consumption and leisure or labor supply. The sign of the parameter  $\rho$  is hard to say a priori due to the ambiguous effects of wage increase on labor supply that has been discussed in the proceeding section. If  $\rho$  is positive, an increase in wage would lower the leisure-consumption ratio and, therefore, imply an increase in labor supply - that is the substitution effect dominates. Conversely, a negative sign of  $\rho$  implies a positive relation between the changes in wage rate and the leisure-consumption ratio, thus reducing labor supply - i.e. income effect dominates.

$$l_t = \left( \frac{w_t}{\alpha} \right)^{-\rho} c_t \quad (2.7)$$

The change of the shadow value,  $\lambda_t$ , with respect to time/age equals the negative first order condition of the Hamiltonian with respect to asset,

$$\frac{\partial \lambda_t}{\partial t} = - \frac{\partial H_t}{\partial a_t} \quad (2.8)$$

Therefore,

$$\lambda_t - \lambda_{t-1} = -\lambda_t r_t \quad (2.9)$$

Re-writing the previous equation, we get

$$\frac{\lambda_t}{\lambda_{t-1}} = \frac{1}{1 + r_t} \quad (2.10)$$

Substituting (2.7) into (2.5), we get an expression for the shadow price  $\lambda_t$  represented by consumption and divided by  $\lambda_{t-1}$ , we get,

$$\frac{\lambda_t}{\lambda_{t-1}} = (1 + \delta)^{-1} \left( \frac{c_t}{c_{t-1}} \right)^{-1/\gamma} \left( \frac{1 + \alpha^\rho w_t^{1-\rho}}{1 + \alpha^\rho w_{t-1}^{1-\rho}} \right)^{\frac{1/\rho - 1/\gamma}{1 - 1/\rho}} \quad (2.11)$$

Equating (2.10) and (2.11), we get two Euler equations for both consumption and leisure, of which, only the latter will be used to derive the labor supply function in the following section.

### 3.2 Labor Supply Function

As previously mentioned, for a single household,  $l$  reflects the fraction of total labor endowment allocated to leisure, thus  $1 - l$  is equivalent to the fraction of total labor endowment spent in market work. This continuous variable corresponds to the intensive margin of labor supply for household.

In a macro-economic context, one has to ensure that the measured labor supply is comparable to that in the theoretical model. The measured labor supply varies across previous empirical studies, which results in inconsistent evidence. As formerly discussed, most of the variations in total man-hours comes from the employment variation, not hours per head (Coleman, 1984). In addition, this paper stresses the effect of wage on the individual labor supply decision at the extensive margin. Hence, I use the number of employed individuals instead of total man-hours as a measurement of labor supply in the aggregate economy.

Furthermore, to make the aggregate measure of labor supply consistent with the theoretical model, I use the employment rate as a proxy for the work-leisure choice

by a single representative agent. This is because  $l$  takes on the value between 0 and 1, so does employment rate.

Let  $e_t$  be time-/age-varying employment rate, which is assumed to be equivalent to a fraction of total labor endowment allocated to market work by a single representative household. Accordingly, the leisure variable for a single household in the aggregate economic context becomes the fraction of the population that is unemployed, thus the aggregate version of leisure can be expressed by  $l_t = 1 - e_t$ . Hence, the dynamic change of leisure at the macro level can be written in the form,

$$\frac{1 - e_t}{1 - e_{t-1}} = \left( \frac{1 + r_t}{1 + \delta} \right)^\gamma \left( \frac{1 + \alpha^\rho w_t^{1-\rho}}{1 + \alpha^\rho w_{t-1}^{1-\rho}} \right)^{\frac{\rho-\gamma}{1-\rho}} \left( \frac{w_t}{w_{t-1}} \right)^{-\rho} \quad (2.12)$$

Taking the logarithm of (2.12), and using the first-order Taylor approximation for  $\ln(1 - e_t)$  and  $\ln(1 + \alpha^\rho w_t^{1-\rho})$ , a linear labor supply function may be written,

$$\ln(e_t) = \ln(e_{t-1}) - \left( \frac{1 - \bar{e}}{\bar{e}} \right) \gamma \ln(1 + r_t) + \left( \frac{1 - \bar{e}}{\bar{e}} \right) \gamma \left( \frac{\rho + \alpha^\rho \gamma}{\gamma + \alpha^\rho \gamma} \right) \ln \left( \frac{w_t}{w_{t-1}} \right) + \tau \quad (2.13)$$

where,  $\bar{e}$  is the parameter in the Taylor approximation for  $\ln(1 - e_t)$ , which can be interpreted as a constant value of labor supply in steady state.  $\tau$  equals  $\left( \frac{1 - \bar{e}}{\bar{e}} \right) \gamma \ln(1 + \delta)$ , which will be captured by a time trend in the empirical estimation.

If the interest rate  $r$  and wage rate  $w$  in (2.13) are adjusted for inflation, the model is similar to L-R model. The only difference is that Lucas and Rapping deleted the interest rate, and therefore explicitly examine the effects of inflation on labor supply, whereas I implicitly assume that both interest and price will be governed by one parameter, thus having the same effect of non-labor income on labor supply. For the model estimation, which will be discussed in more detail in the next section,  $r$  is deflated by the annual percentage change in price index and  $w$  is adjusted at a constant price level.

The advantage of estimating a labor supply function in the form of (2.13) is that it allows me to disentangle the inter-temporal and intra-temporal response to wage change. As discussed earlier, such distinction is important for a life-cycle labor supply analysis, as a wage change can be characterized by an anticipated move along the evolutionary wage path and/or an unanticipated wage shift. If one simply

regressed the measured labor supply on wage rates, the estimated parameter would confound the two types of response. To make this point more explicitly, let  $\beta_1$  represent  $(\frac{1-\bar{\epsilon}}{\bar{\epsilon}})\gamma$  and  $\beta_2$  equal  $(\frac{1-\bar{\epsilon}}{\bar{\epsilon}})\gamma \left( \frac{\rho+\alpha\rho\gamma}{\gamma+\alpha\rho\gamma} \right)$ , (2.13) can therefore be rewritten as,

$$\ln(e_t) = \ln(e_{t-1}) - \beta_1 \ln(1 + r_t) + \beta_2 \ln\left(\frac{w_t}{w_{t-1}}\right) + \tau \quad (2.14)$$

If we merely estimate the model with only wage, not interest rate, the single parameter  $\beta_2$  captures both inter-temporal and intra-temporal responses, making the distinct effects indistinguishable. When both interest and wage are included as explanatory variable (as in the form of (2.14)), the two elasticities,  $\beta_1$  and  $\beta_2$ , can be used to identify the relative magnitude of the two types of response.

### 3.3 Aggregate Demand for Labor

To estimate the labor supply function, such as (2.14), one also needs to derive the rational expectation on wage. This requires specifying a model for the firm sector to derive the labor demand function. Following Lucas and Rapping (1969), I assume the firm sector is a single production sector relying on labor and capital and behaving competitively. The production function is assumed to be in the form of constant elasticity of substitution with constant returns to scale, which can be written as,

$$G_t = \left[ aN_t^{-b} + (1-a)K_t^{-b} \right]^{-\frac{1}{b}} \quad (2.15)$$

where,  $G$ ,  $N$ ,  $K$  are real output, unit of labor and capital inputs at time  $t$ .  $a$  measures the intensity of labor in production.  $1/(1+b)$  is the elasticity of substitution, which reflects the percentage change in capital-labor ratio as a response to the percentage change in the ratio of wage to interest rate.

Given that the firm sector seeks profit maximization under competition, the wage rate is the marginal product of labor, therefore it can be derived by differentiating the real output with respect to the number of labor inputs in (2.15),

$$w_t = \frac{\partial G_t}{\partial N_t} = a \left( \frac{G_t}{N_t} \right)^{1+b} \quad (2.16)$$

Following Lucas and Rapping (1969), by postulating logarithm on (2.16), rearranging the terms, and assuming labor and real output following an order one autoregressive process, the marginal labor productivity condition may be written as,

$$\ln \left( \frac{N_t}{G_t} \right) = \pi_0 - \pi_1 \ln(w_t) + \pi_2 \ln \left( \frac{G_t}{G_{t-1}} \right) + \pi_3 \ln \left( \frac{N_{t-1}}{G_{t-1}} \right) \quad (2.17)$$

Rearranging the terms in (2.17), the aggregate demand for labor ( $N_t$ ) can be expressed by the following function,

$$\ln(N_t) = \pi_0 - \pi_1 \ln(w_t) + \pi_2 \ln \left( \frac{G_t}{G_{t-1}} \right) + \pi_3 \ln \left( \frac{N_{t-1}}{G_{t-1}} \right) + \ln(G_t) \quad (2.18)$$

If we assume the number of employed person reflects the actual demand for labor, then  $N_t = e_t \times P_t$ , where,  $P_t$  is the total population. Hence, (2.18) can be re-written as,

$$\ln(e_t) = \pi_0 - \pi_1 \ln(w_t) + \pi_2 \ln \left( \frac{G_t}{G_{t-1}} \right) + \pi_3 \ln \left( \frac{N_{t-1}}{G_{t-1}} \right) + \ln \left( \frac{G_t}{P_t} \right) \quad (2.19)$$

### 3.4 Reduced Form for Real Wage

Under the assumption that the labor market clears at each period, the demand for the number of workers equals the supply of the number of workers, the reduced form of equation for wage can be derived by equating (2.14) to (2.19), that is,

$$\begin{aligned} \ln(w_t) = & \phi_1 + \phi_2 \ln(e_{t-1}) - \phi_3 \ln(1 + r_t) + \phi_4 \ln(w_{t-1}) \\ & + \phi_5 \ln \left( \frac{G_t}{G_{t-1}} \right) + \phi_6 \ln \left( \frac{N_{t-1}}{G_{t-1}} \right) + \phi_7 \ln \left( \frac{G_t}{P_t} \right) + \tau + u_t \end{aligned} \quad (2.20)$$

### 3.5 Theoretical Prediction of Model Parameters

The proceeding theoretical discussion on the real wage and labor supply gives two main predictions. First, the sign of the intra-temporal elasticity of labor supply w.r.t wage can be either positive or negative depending on whether income or substitution effects dominate. Second, the sign of the inter-temporal elasticity of

labor supply w.r.t wage can only be positive as this is the labor supply response to evolutionary wage rate, which is known to the household, i.e. only substitution effects.

There is no theoretical prediction of the relative magnitude of inter-temporal and intra-temporal elasticities. Hence, statistical inference on the two parameter estimates will be conducted. In order to quantify the relative magnitude of inter-temporal and intra-temporal response, I assume that  $\alpha = 1$ , household's utility weight on leisure is equal to that of consumption.<sup>4</sup> Thus, the relative magnitude can be written as  $\frac{\rho}{\gamma} = \frac{2\beta_2}{\beta_1} - 1$ . Given this, the hypotheses are as follows:

Hypothesis 1: If  $\frac{\beta_2}{\beta_1} > 1$ , the substitution effect dominates within period, and the intra-temporal elasticity outweighs the inter-temporal elasticity of labor supply w.r.t wage increase, i.e  $\frac{\rho}{\gamma} > 1$ .

Hypothesis 2: If  $\frac{1}{2} < \frac{\beta_2}{\beta_1} < 1$ , the substitution effect dominates within period, but the intra-temporal elasticity is outweighed by the inter-temporal elasticity of labor supply w.r.t wage increase, i.e  $0 < \frac{\rho}{\gamma} < 1$ .

Hypothesis 3: If  $0 < \frac{\beta_2}{\beta_1} < \frac{1}{2}$ , the income effect dominates within period, but the intra-temporal elasticity is outweighed by the inter-temporal elasticity of labor supply w.r.t wage increase, i.e  $-1 < \frac{\rho}{\gamma} < 0$ .

Hypothesis 4: If  $\frac{\beta_2}{\beta_1} < 0$ , the income effect dominates within period, and the intra-temporal elasticity outweighs the inter-temporal elasticity of labor supply w.r.t wage increase, i.e  $\frac{\rho}{\gamma} < -1$ .

Hypothesis 5: If  $\frac{\beta_2}{\beta_1} = 1$ , i.e.  $\beta_2 = \beta_1$ , the intra-temporal elasticity equals the inter-temporal elasticity of labor supply w.r.t wage increase, i.e  $\frac{\rho}{\gamma} = 1$ .

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<sup>4</sup>The  $\alpha$  parameter represents the weight of household's utility attached to leisure relative to consumption. Were  $\alpha$  greater than one, household prefer leisure to consumption, thus supply less labor. Conversely, if  $\alpha$  is smaller than one, but greater than zero, household prefer consumption to leisure, and therefore supply more labor. Two special cases are when  $\alpha$  equals zero and one. The former refers to the fix labor supply assumption, in which, household would choose no leisure, thus it reduces to a constant relative risk aversion utility function (CRRA). The latter refers to the assumption of equal utility weight on leisure and consumption, that is household would be indifferent by consuming one unit of good or leisure, *ceteris paribus*. As can be seen in (2.7), were  $\alpha$  equals one, the leisure-consumption choice is only influenced by the wage rates and governed by the parameter of intra-temporal elasticity.

### 3.6 Empirical Evidence of Model Parameters

Table 2.1 summarizes the model estimates from Lucas and Rapping (1969) and Alogoskoufis (1987), both of which are based on the US aggregate time-series data. The first column shows the estimates for the reduced form for wage equation corresponding to (2.20). The coefficients in the second to the fourth columns are for the labor supply functions similar to (2.14). Noticeably, the estimated impact of wage on labor supply is larger in Lucas and Rapping (1969) compared to Alogoskoufis (1987). This partly due to the differences in the measurements of labor supply, as the former used aggregate total man-hours, while the latter used employment rates.

**Table 2.1:** Evidence from Previous Empirical Studies

VARIABLES	Lucas and Rapping (1969)		Alogoskoufis (1987)	
	Reduced Form $\ln(w_t)$	Man-hours $\ln(h_t)$	Employment Rate $\ln(e_t)$	Employment Rate $\ln(e_t)$
$\ln(w_t)$	x	1.4	0.9	0.91
$\ln(w_{t-1})$	0.44	-1.39	-0.85	-0.91
$\ln(1 + r_t)$	x	x	0.34	0.35
$\ln(h_{t-1})$	-1.15	0.64	x	x
$\ln(e_{t-1})$	x	x	1.01	1.00
$\ln\left(\frac{G_t}{G_{t-1}}\right)$	-1.22	x	x	x
$\ln\left(\frac{N_{t-1}}{G_{t-1}}\right)$	1.24	x	x	x
$\ln\left(\frac{G_t}{P_t}\right)$	1.25	x	x	x
Coef. Constraints	x	x	x	$\ln(w_t) = \ln(w_{t-1})$ $\ln(e_{t-1}) = 1$

It is noteworthy that the difference between the two models in Alogoskoufis (1987) using employment rate as dependent variable is that one of them imposes two re-



restrictions on the parameters: the coefficients on the current and lagged wage are equal to each other, and the lagged employment rate is constrained to 1. Such restriction allow the author to compare the relative magnitude of the inter- and intra-temporal elasticity of substitution. Based on their parameter estimates, the ratio  $\frac{\rho}{\gamma}$  is 4.2 suggesting that the static elasticity of substitution between consumption and leisure is more than 4 times greater than the inter-temporal elasticity of substitution.

The two empirical studies reviewed here suggest that the short-run labor supply elasticity with respect to wage is positive, and around unity. Lucas and Rapping (1969) obtained large estimates, 1.4, and further claimed that the Keynesian type assumption of elastic short-run labor supply is valid. Alogoskoufis (1987), on the other hand, showed that intra-temporal elasticity of substitution outweighs the inter-temporal elasticity.

## 4 Data and Methods

### 4.1 National Transfer Accounts Sweden 1985-2003

The age profile of labor income in the National Transfer Accounts (NTA) is a comprehensive measure of the age differentials in market value of total labor supply weighted by all members of a population in a particular age group (Lee and Ogawa, 2011). By definition, NTA labor income includes employees' labor earnings, self-employed labor income, fringe benefits, and payroll tax contributed by employers. The NTA time-series for Sweden comprises repeated cross-sectional age profiles over the period 1985-2003. For each year, the relationship between the total and age-specific labor income at the aggregate level can be expressed as,

$$Y_t = \sum_x Y_{x,t} = \sum_x w_{x,t} \times E_{x,t} \quad (2.21)$$

where,  $x$  and  $t$  denote age and time, respectively. Let  $Y$  be the aggregate annual labor income,  $E$  be the number of employed person in the economy, and  $w$  be de facto annual wage per employee.

Equation (2.21) implies that the NTA age-specific labor income is a product of de facto annual wage for those who are employed and number of employees in the

same age group. That is,

$$Y_{x,t} = w_{x,t} \times E_{x,t} = w_{x,t} \times \frac{E_{x,t}}{P_{x,t}} \times P_{x,t} \quad (2.22)$$

where,  $P_{x,t}$  is the age-specific population at time  $t$ .

It is evident from (2.22) that the aggregate age-specific labor income ( $Y_{x,t}$ ) based on NTA definition confounds the effects of market wage rate ( $w_{x,t}$ ), the employment rate ( $\frac{E_{x,t}}{P_{x,t}}$ ), and the population size in each age group  $P_{x,t}$ . Dividing (2.22) by age-specific population on both sides yields per capita age-specific labor income as a function of wage rate times employment rate,

$$y_{x,t} = w_{x,t} \times \frac{E_{x,t}}{P_{x,t}} = w_{x,t} \times e_{x,t} \quad (2.23)$$

where,  $e_{x,t}$  denotes employment rate for each age group at time  $t$ .

From (2.23), it is obvious that the difference between the NTA labor income and the conventional wage rate is by a factor of employment rate. Both would be equivalent, if, and only if, the condition of full employment is satisfied. That is the equilibrium wage rate at market clearing level of no voluntary and involuntary unemployment. In this regard, NTA provides a consistent framework with general equilibrium theory by linking population structure and aggregate national income. The empirical data, however, suggests that unemployment always exists; therefore, NTA labor income shall not be analysed solely. It is necessary to look at the variation in these decomposed components, wage and employment rates, to better understand the dynamic age-profiles of labor income overtime.

The NTA time-series for Sweden provides information on per capita age-specific labor income for each year between 1985 and 2003, i.e.  $y_{x,t}$  in (2.23). The wage rate per employed person,  $w_{x,t}$ , is then calculated by dividing  $y_{x,t}$  by the employment rate,  $e_{x,t}$  for each age and time. Unfortunately, the employment rates provided by Statistics Sweden are aggregated by following age groups: 16-19, 20-24, 25-34, 35-44, 45-54, 55-59, and 60-64, hence the derived wage rates are computed in accordance with these age groups. All wage rates are adjusted to the price level in year 1985. The price information was obtained from Statistic Sweden. Furthermore, I use a series of short-run annual yield as a proxy for asset return  $r$  in (2.14), which are extracted from the Annual Swedish stock prices and returns, and bond yields 1856-2006 by Swedish Riksbank.

## 4.2 Age Profiles over Time

To examine the changing age distribution of work compensation and employment rate overtime, the data are fitted by Lee-Carter method (Lee and Carter, 1992). Doing so allows me to capture the changing shape of life-cycle wage rates and labor supply, and investigate the age-specific responses to overall trends of the two variables.

There have been dramatic social and economic changes over the investigation period: the economic crisis from year 1990 to 1993, the new legislation of the pension system in the year 1994 (moving towards a notional defined contribution model), and its implementation in the early 2000s. As a result, the time-varying age profiles are fit for four sub-periods, which are 1985-89, 1990-93, 1994-99 and 2000-03, in order to account for the impact of changing macroeconomic and institutional condition.

## 4.3 Estimating Labor Supply Function

### Population Composition Index

The yearly variation in number of employed persons, such as  $E$  in (2.22), may be influenced by change in labor force composition over time, such as the time-varying distributions of age, gender, and education, etc. If such compositional effects exist, the estimated elasticity of labor supply with respect to wage may be biased. Thus, following Lucas and Rapping (1969), the annual number of employed person  $E$  is deflated by the population compositional index  $M$ , which may be written as,

$$M_t = \frac{\sum_{i=1}^n \left( \frac{E_{0,i}}{P_{0,i}} \right) \times P_{t,i}}{E_0} \quad (2.24)$$

where, subscript  $t$  and  $i$  is time and each of the population subgroups,<sup>5</sup> respectively.  $E$  and  $P$  are number of employed person and population. Subscript 0 refers to the initial time period.

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<sup>5</sup>The subgroups are similar to Lucas and Rapping (1969).  $i$ 's refer to 14 age-gender groups, that is male and female for each of the age groups categorized by Statistics Sweden in their reported annual employment rates: 16-19, 20-24, 25-34, 35-44, 45-54, 55-59, and 60-64.

As Lucas and Rapping (1969) argued, this index generates a counter-factual variable that reflects the relative increase in the labor force that would have occurred solely due to the variation in population composition, holding the group-specific employment rates constant. Therefore, deflating  $E$  by  $M$  will eliminate the impact of population compositional changes on number of employed person.

### Aggregate Time-Series Estimation

As formerly argued, since  $E$  needs to be deflated by  $M$ , employment and wage rates follow the same procedure. Thus (2.14) may be rewritten as,

$$\ln(e_t/M_t) = \ln(e_{t-1}/M_{t-1}) - \beta_1 \ln(1 + r_t) + \beta_2 \ln\left(\frac{w_t/M_t}{w_{t-1}/M_{t-1}}\right) + \tau + \epsilon_t \quad (2.25)$$

And accordingly, the reduced form equation for wage becomes,

$$\begin{aligned} \ln(w_t) = & \phi_1 + \phi_2 \ln(e_{t-1}/M_{t-1}) - \phi_3 \ln(1 + r_t) + \phi_4 \ln(w_{t-1}/M_{t-1}) \\ & + \phi_5 \ln\left(\frac{G_t}{G_{t-1}}\right) + \phi_6 \ln\left(\frac{N_{t-1}}{G_{t-1}}\right) + \phi_7 \ln\left(\frac{G_t}{P_t M_t}\right) + \tau + u_t \end{aligned} \quad (2.26)$$

The price and interest rate are assumed to be exogenous to household in this model, while labor supply and wage rates are endogenous. Two Stage Least Square (2SLS) is applied to estimate the elasticity of labor supply with respect to wage,  $\beta_2$  in (2.25). Equation (2.26) is estimated at the first stage to form the households expectation on wage. The instrumental variables in the reduced-form equation are  $\ln\left(\frac{G_t}{G_{t-1}}\right)$ ,  $\ln\left(\frac{N_{t-1}}{G_{t-1}}\right)$ , and  $\ln\left(\frac{G_t}{P_t M_t}\right)$ . I use the Annual Gross Domestic Product (GDP), collected by Statistics Sweden, as a proxy for total output  $G$ . The series is deflated by price index with base year 1985.

It is important to note that the variables  $G$ ,  $N$ ,  $P$ , and  $M$  are assumed to be exogenous to wage. The theoretical model presented earlier assumes that wage is determined by the firm sector based on their total output  $G$  and demand for labor  $N$ . However, one might argue that population size  $P$  as well as population composition index  $M$  are endogenous to wage as fertility, mortality and migration might be influenced by income. Nevertheless, following Lucas and Rapping

(1969), they are treated as predetermined factors based on the argument that current demographic pattern, particularly for fertility and mortality, are the result of past decisions that depend partly on past wage. Furthermore, the wage impact on demographic outcomes might take decades to exert. Therefore,  $P$  and  $M$  are regarded as exogenous to current wage.

The interpretation of the three instruments in (2.26) is straightforward.  $\ln \left( \frac{G_t}{G_{t-1}} \right)$  is the annual growth rate of the economy.  $\ln \left( \frac{N_{t-1}}{G_{t-1}} \right)$  reflects the units of labor input for each unit of output, i.e. the marginal productivity condition for labor.  $\ln \left( \frac{G_t}{P_t M_t} \right)$  is the GDP per capita deflated by population composition index, the counter-factual per capita output in the economy that are not driven by change in population composition.

Equation (2.25) is identical to the model estimated by Alogoskoufis (1987), presented in the last column in Table 2.1. This is a restricted model with two coefficient constraints allowing for testing hypothesis 1-5. A more general labor supply function, the unrestricted model in the form of (2.27), is also estimated and reported in the following section. This model is similar to the two models by Alogoskoufis (1987) presented in the column 2 and 3 in Table 2.1.

$$\begin{aligned} \ln(e_t/M_t) = & \theta_0 + \theta_1 \ln(e_{t-1}/M_{t-1}) - \theta_2 \ln(1 + r_t) \\ & + \theta_3 \ln(w_t/M_t) - \theta_4 \ln(w_{t-1}/M_{t-1}) + \tau + \epsilon_t \end{aligned} \quad (2.27)$$

It is important to stress that the estimation using (2.25), (2.27), and (2.26) corresponds to a single representative household. In the estimation, the wage and employment rates are aggregated over all age groups. Thus the estimated elasticity is consistent with the aforementioned theoretical model and is comparable with the previous empirical evidence summarized in Table 2.1. For the age-specific analysis, model modifications are illustrated in the next section.

### Age-Specific Time-Series Estimation

To estimate the age-specific labor supply function, certain adjustments need to be made in order to make the model and data compatible.

The NTA time series data is in the form of repeated cross-sections of age-specific labor income over time. Ideally, it would be beneficial to estimate the data with

either age-specific cohort or cohort-specific period perspective so that they would reflect more realistic life-cycle dynamics. However, given the aggregation of the employment rates into multi-year age groups and the limited time span of the data, such an analysis is infeasible. Presently, the only option is to pursue the analysis in an age-specific period setting. Although this strategy is inferior to a synthetic cohort analysis, it is certainly superior to aggregate time-series analysis. The estimated elasticities can be distinguishable by age groups, potentially providing better insights into how the elasticity of labor supply with respect to wage may differ at various stages of the life-cycle.

Given the age-specific period setting, equations (2.25), (2.26), and (2.27) are modified in the following way. Let  $x$  be age and  $t$  be calendar time, the estimation equation for age-specific labor supply based on (2.25) is,

$$\begin{aligned} \ln(e_{x,t}/M_t) = & \ln(e_{x,t-1}/M_{t-1}) - \beta_{x,1} \ln(1 + r_t) \\ & + \beta_{x,2} \ln\left(\frac{w_{x,t}/M_t}{w_{x,t-1}/M_{t-1}}\right) + \tau_x + \epsilon_{x,t} \end{aligned} \quad (2.28)$$

And the reduced-form equation for age-specific wage corresponding to (2.26) is,

$$\begin{aligned} \ln(w_{x,t}) = & \phi_{x,1} + \phi_{x,2} \ln(e_{x,t-1}/M_{t-1}) - \phi_{x,3} \ln(1 + r_t) + \phi_{x,4} \ln(w_{x,t-1}) \\ & + \phi_{x,5} \ln\left(\frac{G_t}{G_{t-1}}\right) + \phi_{x,6} \ln\left(\frac{N_{t-1}}{G_{t-1}}\right) + \phi_{x,7} \ln\left(\frac{G_t}{P_t M_t}\right) + \tau_x + u_{x,t} \end{aligned} \quad (2.29)$$

For the unrestricted model, (2.27), the corresponding age-specific equation may be written as,

$$\begin{aligned} \ln(e_{x,t}/M_t) = & \theta_{x,0} + \theta_{x,1} \ln(e_{x,t-1}/M_{t-1}) - \theta_{x,2} \ln(1 + r_t) \\ & + \theta_{x,3} \ln(w_{x,t}/M_t) - \theta_{x,4} \ln(w_{x,t-1}/M_{t-1}) + \tau_x + \epsilon_{x,t} \end{aligned} \quad (2.30)$$

The main difference between the aggregate and age-specific time-series equations is that the two endogenous variables, employment rates and wage, are disaggregated into age-groups. It must be noted that the elasticity estimated by such a specification does not reflect the actual life-cycle behavior, as the age-specific variables only vary over time, not age. To interpret the parameter as inter-temporal elasticity of substitution, one has to assume that a change in the age-specific variable over

time (between  $x, t$  and  $x, t + 1$ ) approximately equal a change across age-period (between  $x, t$  and  $x + 1, t + 1$ ).

All the variables assumed to be exogenous ( $M, r, G, N, P$ ) are measured at the aggregate level. This, in fact, assumes that households at the different ages are exposed to identical macroeconomic condition at each time period, but are affected differently.

Parameters in the reduced-form equation (2.29) shall be interpreted as the age-specific effect of aggregate economic change on wages. In turn, this forms the wage expectation for each age group, and relates it to the age-specific employment rates. The age-specific elasticity estimates are not equivalent to the theoretical model presented earlier. Nor are they directly comparable with the estimates in Table 2.1. Nonetheless, decomposed elasticities by age are useful for addressing the question whether labor supply response to wage differs over the life-cycle. More importantly, is it necessary to calibrate an array of life-cycle or age-specific elasticities in the OLG model?

As already mentioned, an age-specific period setting might not be ideal for studying life-cycle behavior. Year-to-year variation might only approximate behavioral modification over the life-cycle. Since the data is treated as in the age-specific period rather than cohort-specific period setting, the parameters ( $\beta_{x,2}$  and  $\theta_{x,3}$  in (2.28) and (2.30), respectively) shall be interpreted as a vector of “Quasi” life-cycle labor supply elasticities.

## 5 Results and Discussion

### 5.1 Some Descriptive Results

Figure 2.1 and 2.2 illustrate the predicted average age-profiles of real wage and employment rates by sub-periods, respectively, using Lee-Carter Method. In general, the wage rate is consistently higher for old workers than young workers, which is in line with predictions by the theories reviewed in the previous section; however, the pattern appears to be shifting towards older age over time.

Up until 1999, the age-earning profiles are characterized by a steep increase from labor market entry age, peaking at age 45-54, and gradually declining thereafter.

This pattern is in line with Skirbekk's summary of OECD evidence that wage peaks for the age group 45-54 in 17 out of the 19 OECD countries (Skirbekk, 2003).<sup>6</sup>

This pattern, however, was altered over 2000-2003. As the light grey line in Figure 2.1 illustrates, the peaking age shifted from age 45-54 to 55-59, and earnings remained high through age 64. This is somewhat similar to the findings by (Lee et al., 2011) for the U.S. where the earnings of older men are consistently trending upward relative to younger men. One of the explanations could be, as given by (Lee et al., 2011), that young workers no longer possess an educational advantage over old workers.

On the other hand, this can be also attributable to the factors such as the existence of wage-productivity discrepancy, efficiency wage hypothesis, the shirking model, the nature of the optimal wage profile, working experience, and the trade union preference given to older workers. All such factors can contribute to a higher work compensation for senior relative to junior workers.

By looking at Figure 2.1 and 2.2 simultaneously, wage and employment over the life-cycle both appear hump shaped. This is in line with ISH prediction that wage and labor supply should be positively correlated; however, the rate of change for the two life-cycle series do vary at different ages. From age 16 to 34, employment rate grows more or less at the same pace as wages. But the employment curve flattens out between age 35 and 54, while the wage curve continuously trends upward.

The most striking feature is the divergence between employment and wage after age 54. The decline of the employment is too steep to be explained by the decreasing wage. This divergence seems to amplify over time, particularly for the most recent period (2000-03), in which, employment drops considerably while wage rates flatten out between age 54 and 64. All of this evidence implies that ISH might not fully explain the labor supply over the entire life-cycle. It falls short in explaining the sharp decline in employment after age 54.

Figure 2.3 shows the relative age-specific contribution to the overall change in wage and employment over the period 1985-2003. If we look at the youngest and the oldest in this figure, it is evident that the wage and labor supply responses are negatively associated. For those aged 16-19, wage growth is nearly zero with respect

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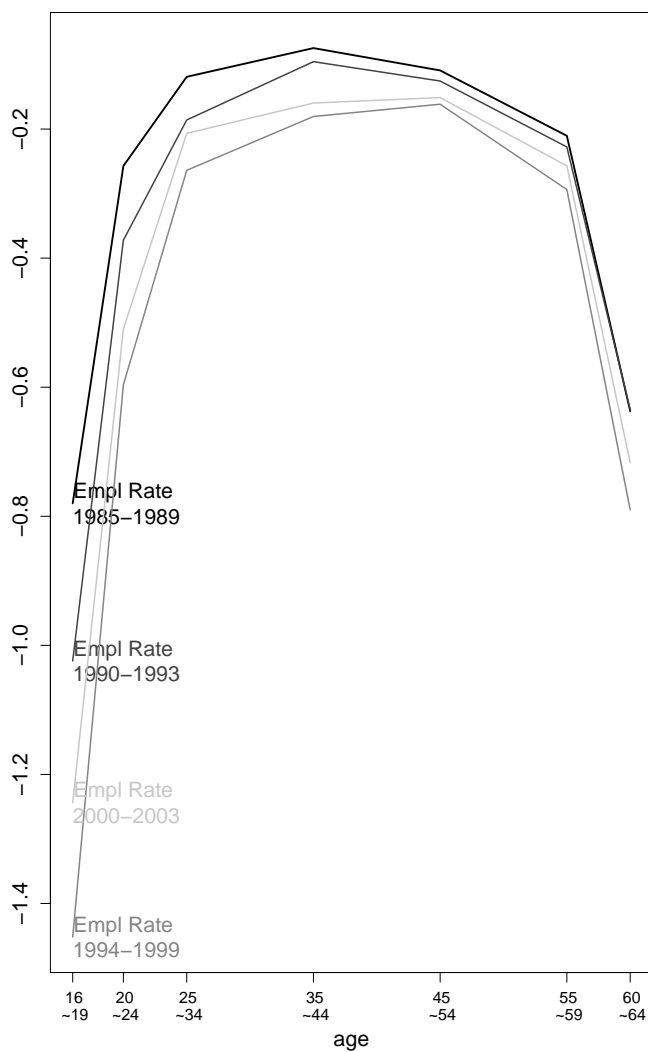
<sup>6</sup>These countries are Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Mexico, The Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland and the U.S.



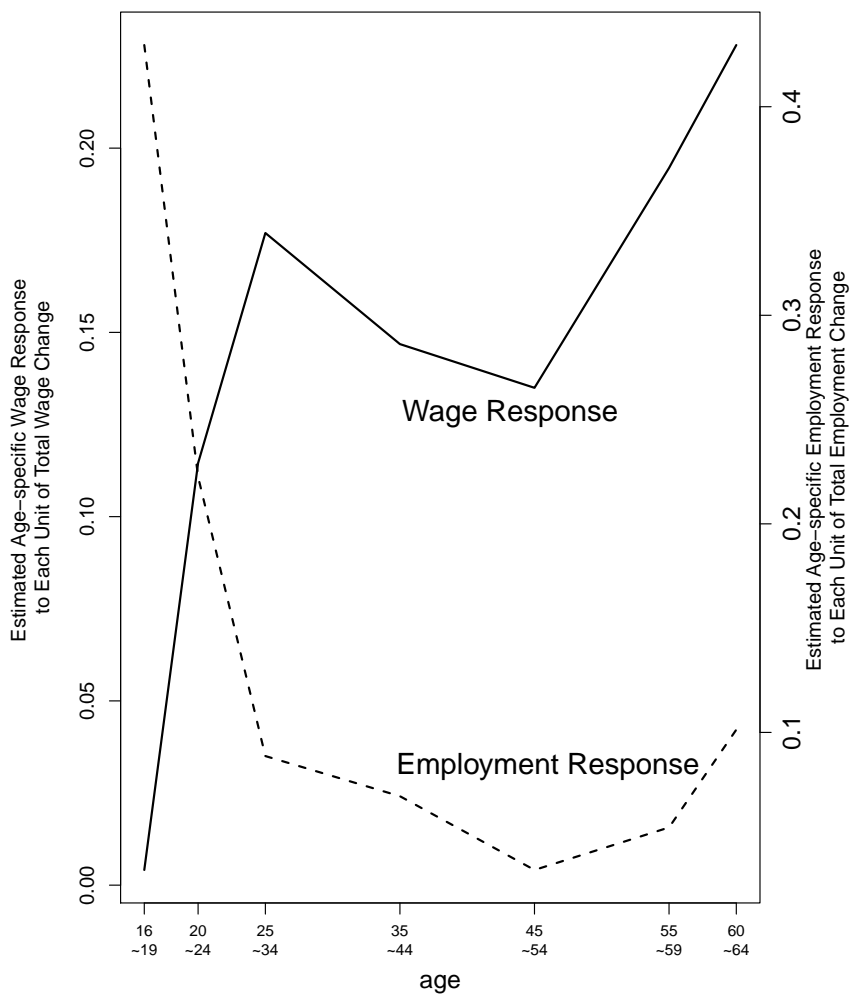
to one unit change in aggregate wage rate, whereas employment changed by over 40 percent for each unit change in aggregate employment rate. On the other extreme, those aged 60-64 would gain by over 20 percent for each unit increase of overall wage, which is more than doubled of their employment response.



**Figure 2.1:** Fitted age profiles of per capita real wage (log scale) by sub-periods using Lee-Carter Method



**Figure 2.2:** Fitted age profiles of labor force participation rate (log scale) by sub-periods using Lee-Carter method



**Figure 2.3:** Comparison of fitted age-specific responsiveness in real wage and labor force participation 1985-2003

## 5.2 Estimated Elasticities of Labor Supply w.r.t Real Wage

### Aggregate Estimates

The estimates reported in Table 2.2 are comparable to those summarized in Table 2.1, as they are all obtained based on aggregate time-series data and equivalent to the labor supply of a single representative household.

**Table 2.2:** Estimation of Aggregate Time-series Data, Reduced Form (2.26), Labor Supply (2.25) and (2.27)

VARIABLES	(2.26) $\ln(w_t)$	(2.25) $\ln(e_t/M_t)$	(2.27) $\ln(e_t/M_t)$
$\ln(w_t/M_t)$		0.759** (0.299)	0.916 (0.645)
$\ln(w_{t-1}/M_{t-1})$	0.669* (0.362)	-0.759** (0.299)	-0.424 (0.695)
$\ln(1 + r_t)$	0.069 (0.281)	-0.555*** (0.115)	-0.155 (0.290)
$\ln(e_{t-1}/M_{t-1})$	-2.076 (1.580)	1	0.935*** (0.240)
$\ln(G_t/G_{t-1})$	-1.813 (1.639)		
$\ln(N_{t-1}/G_{t-1})$	1.756 (1.730)		
$\ln(G_t/P_t M_t)$	2.064 (1.668)		
$\tau$	0.000 (0.009)	-0.001 (0.001)	-0.012** (0.005)
Constant	-0.102 (16.289)	1.550 (1.401)	21.052** (9.766)
Observations	18	18	18
R-squared	0.987		0.937
F-test (p-value)		0.525	
$\frac{\rho}{\gamma}$		1.732	
Overid sargan (p-value)			0.244

Standard errors in parentheses

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

Overid: Sargan over-identification test.

F-test: equality test for hypothesis 5:  $H_0: \beta_1 = \beta_2$  ( $\rho = \gamma$ )

$\frac{\rho}{\gamma}$ : the relative magnitude of intra- to inter-temporal elasticity.

The reduced form estimates presented in the first column in Table 2.2 have the same signs as those estimated by Lucas and Rapping (1969) (see Table 2.1, first column). The magnitude of the coefficients, however, are much larger than those reported by Lucas and Rapping (1969). I further applied the Sargan-Hansen test (see Overid sargan in Table 2.2) to verify the validity of the instruments. For all three instruments, I did not reject the null hypothesis that these instruments are valid, uncorrelated with the error term, and correctly excluded from the labor supply estimation equation.

The second and third column of Table 2.2 report the parameter estimates of the labor supply function (2.25) and (2.27), respectively. The estimated elasticity of labor supply is 0.76, which is not far from the elasticity reported by Alogoskoufis (1987) (see the last column of Table 2.1). The unrestricted elasticity (0.92) is the same as in the third column of Table 2.1. Both my estimates of labor supply elasticity and those from Alogoskoufis (1987) are less than unity; however, the ones reported in Lucas and Rapping (1969) are much larger. This might be partly due to the differences in measured labor supply, i.e. man-hours versus employment rate.

The time trend,  $\tau$ , captures factors that might shift the constant over time. These factors are the steady state labor supply in the Taylor approximation  $\frac{1-\bar{z}}{\bar{e}}$ , the inter-temporal elasticity of substitution  $\gamma$ , and the rate of time preference  $\ln(1 + \delta)$ . Since  $\gamma$  and  $\ln(1 + \delta)$  are theoretically positive, the estimated negative time trend in both restricted and unrestricted models (see  $\tau$  in the second and third column of Table 2.2) implies that the constant in the Taylor approximation or the steady-state labor supply follows a downward trend over time. Such downward trend is in line with the pattern shown in Figure 2.2 that employment rates drop at all ages from the early 90s to the 2000s.

In terms of the relative magnitude of intra- to inter-temporal elasticity, the estimated  $\frac{\rho}{\gamma}$  in Table 2.2 suggests that the intra-temporal outweighs the inter-temporal elasticity of substitution, a finding is similar to Alogoskoufis (1987). According to his coefficient estimates in the restricted model, column 3 in Table 2.1, the  $\frac{\rho}{\gamma}$  is 4.2. The estimate of this ratio in the present study is lower, 1.7, suggesting that the static elasticity of substitution between consumption and leisure is 70 percent greater than the inter-temporal elasticity of substitution; however, this inequality does not hold statistically. The F-test in Table 2.2 does not reject the equality test between  $\rho$  and  $\gamma$  implying that intra-temporal and inter-temporal elasticity of

substitution are statistically the same and confirming that hypothesis 5 is valid.

### Age-Specific Estimates

The parameters by age-specific estimation do vary across age groups in both the reduced form wage equation and the labor supply function. Table 2.3 reports the coefficients for the age-specific reduced form equation. The most striking feature is the disproportional wage impact of macro-economic conditions across different age groups. The annual economic growth, the marginal productivity condition for labor, and the population composition adjusted GDP per capita all reveal much larger effects on wages for those under age 34 than their older counterparts (see  $\ln(G_t/G_{t-1})$ ,  $\ln(N_{t-1}/G_{t-1})$ , and  $\ln(G_t/P_t M_t)$  in the first three column of Table 2.3).

**Table 2.3:** Estimation of Age-Specific Time-series Data, Reduced Form Eq. (2.29)

VARIABLES	16-19	20-24	25-34	35-44 $\ln(w_{x,t})$	45-54	55-59	60-64
$\ln(w_{x,t-1}/M_{t-1})$	-0.001 (0.365)	0.660** (0.210)	0.211 (0.283)	0.559 (0.363)	0.349 (0.338)	0.521 (0.352)	0.804* (0.391)
$\ln(1 + r_t)$	-0.497 (1.719)	0.244 (0.443)	0.425 (0.258)	-0.106 (0.340)	0.096 (0.304)	-0.003 (0.326)	0.306 (0.606)
$\ln(e_{x,t-1}/M_{t-1})$	3.197 (1.988)	0.424 (0.594)	2.647** (1.037)	-1.236 (0.950)	0.874 (1.786)	-0.660 (0.791)	-0.329 (0.577)
$\ln(G_t/G_{t-1})$	12.604 (9.421)	1.237 (1.588)	2.825** (0.948)	-0.563 (0.795)	0.472 (0.787)	-0.090 (0.594)	0.281 (0.860)
$\ln(N_{t-1}/G_{t-1})$	-11.428 (7.934)	-1.723 (1.648)	-3.899** (1.257)	0.695 (0.972)	-0.807 (0.786)	0.054 (1.057)	0.221 (1.644)
$\ln(G_t/P_t M_t)$	-11.090 (8.550)	-0.744 (1.586)	-2.884** (1.097)	0.890 (0.800)	-0.373 (0.815)	0.403 (0.700)	0.172 (1.181)
$\tau_x$	-0.010 (0.064)	-0.016 (0.015)	-0.007 (0.009)	-0.000 (0.010)	0.003 (0.011)	0.004 (0.011)	0.006 (0.027)
Constant	23.835 (109.523)	27.437 (27.143)	11.870 (15.065)	1.821 (17.637)	-5.250 (19.229)	-6.563 (19.539)	-11.246 (47.655)
Observations	18	18	18	18	18	18	18
R-squared	0.825	0.944	0.990	0.975	0.969	0.988	0.970

Standard errors in parentheses

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

Another important note is the age-specific time trends ( $\tau_x$  in Table 2.3) show that wages follow a downward trend for those under the age of 34, whereas an upward trend for 45+ over the period 1985-2003. This is similar to the findings by Lee et al. (2011) for the U.S. that earnings of older men are consistently upward trending relative to the young men. It is important to stress that the wage rates are deflated by the population composition index, thus the wage effects of macro-economic variation as well as the long-term trend do not confound any impact from the age-gender distributional change in the population.

Table 2.4 reports the coefficient estimates of unrestricted labor supply function corresponding to equation (2.30). From the first row in Table 2.4, the short-run labor supply elasticity with respect to real wage differ considerably across age groups. Individuals aged 16-24 appear to have relatively elastic supply schedule compared to older workers. Following the interpretation of this elasticity by Lucas and Rapping (1969), the Keynesian assumption of a relatively elastic short-run supply schedule is only confirmed by the workers aged 34 or younger.

**Table 2.4:** Estimation of Age-Specific Time-series Data, Unrestricted Eq. (2.30)

VARIABLES	16-19	20-24	25-34	35-44	45-54	55-59	60-64
	$\ln(e_{x,t}/M_t)$						
$\ln(w_{x,t}/M_t)$	1.169** (0.529)	1.539*** (0.423)	0.390* (0.201)	0.934 (0.628)	0.422** (0.213)	0.978 (0.670)	0.710 (1.688)
$\ln(w_{x,t-1}/M_{t-1})$	-0.390 (0.266)	-1.047** (0.475)	-0.030 (0.259)	-0.583 (0.611)	-0.092 (0.132)	-0.475 (0.621)	-0.321 (1.509)
$\ln(1 + r_t)$	-0.288 (1.747)	-0.486 (0.619)	-0.132 (0.205)	0.067 (0.263)	-0.085 (0.151)	0.092 (0.288)	-0.664 (0.858)
$\ln(e_{x,t-1}/M_{t-1})$	0.109 (0.448)	0.731*** (0.188)	0.639*** (0.158)	1.201*** (0.350)	0.818*** (0.171)	1.209*** (0.329)	1.267* (0.651)
$\tau_x$	-0.037* (0.019)	-0.015** (0.008)	-0.013*** (0.004)	-0.004 (0.004)	-0.007** (0.004)	-0.011** (0.005)	-0.008 (0.005)
Constant	68.748* (35.782)	26.993** (13.580)	22.536*** (7.016)	6.240 (8.527)	11.587* (5.942)	19.242** (9.507)	12.878 (9.591)
Observations	18	18	18	18	18	18	18
R-squared	0.821	0.921	0.966	0.925	0.937	0.870	0.814
Overid Sargan	4.560	0.677	8.369	0.862	3.334	0.919	1.237
Sargan p-value	0.102	0.713	0.0152	0.650	0.189	0.632	0.539

Standard errors in parentheses

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

Overid: Sargan over-identification test.

Age group 35-44 and 55-59 are the only groups whose labor supply elasticities (around 0.9) are close to the aggregate estimate in the third column of Table 2.2. This implies that the aggregate time-series estimation does not capture the age-differences in labor supply elasticity. Multi-generational models, such as OLG, might need an array of age-specific parameters to reflect the behavioral differences across different stages of the life-cycle.

The estimates for the restricted labor supply model, equation (2.28), are reported in Table 2.5. As discussed earlier, the parameter constraints allow us to examine the relative magnitude of intra- and inter-temporal elasticity by the ratio  $\rho/\gamma$ . This ratio also varies with age, as shown in the last row of Table 2.5. The aggregate time-series estimates of this ratio is 1.7 (see  $\rho/\gamma$  in Table 2.2), however, this is only confirmed by age groups: 20-24, 25-34, 35-44, and 55-59, as their estimates are all greater than one. This suggest that the static elasticity of substitution between consumption and leisure outweighs the inter-temporal elasticity of substitution, Hypothesis 1. However, the equality test of  $\rho$  and  $\gamma$  (see F-test in Table 2.5) suggests that the intra- and inter-temporal elasticity is statistically equal to each other, Hypothesis 5, except for the oldest age group.

The  $\rho/\gamma$  ratio for those aged between 60 and 64 is -1.5 implying that the static elasticity outweighs the inter-temporal elasticity and it is further dominated by the income effects. This provides somewhat supporting evidence for the backward-bending labor supply curve discussed in the earlier section; however, this estimate needs to be interpreted with cautious because this age group is most likely in the retirement transition. Unfortunately the data does not allow to incorporate the economic incentives for retirement in the estimation, thus it is very likely that the wage effect on the labor supply is overestimated. One may expect the income effects to diminish if pensions and/or other non-labor related social benefits for the elderly are controlled for in.

## 6 Conclusion

To assess the economic consequences of population ageing and evaluate viable solutions, a thorough consideration of labor supply behavior is necessary. Hence, this paper examines the macro behavior of real wage and labor supply in the Swedish labor market over the period 1985-2003. The descriptive analysis shows that labor supply measured by employment rate does not strongly correlated with



**Table 2.5:** Estimation of Age-Specific Time-series Data, Restricted Eq. (2.28)

VARIABLES	16-19	20-24	25-34	35-44 $\ln(e_{x,t}/M_t)$	45-54	55-59	60-64
$\ln(w_{x,t}/M_t)$	0.381 (0.253)	1.470*** (0.350)	0.593** (0.231)	0.331 (0.192)	0.099 (0.088)	0.236 (0.236)	-0.230 (0.332)
$\ln(w_{x,t-1}/M_{t-1})$	-0.381 (0.253)	-1.470*** (0.350)	-0.593** (0.231)	-0.331 (0.192)	-0.099 (0.088)	-0.236 (0.236)	0.230 (0.332)
$\ln(1 + r_t)$	-0.782 (1.263)	-0.870*** (0.239)	-0.479*** (0.091)	-0.272** (0.100)	-0.150* (0.072)	-0.227** (0.088)	-0.929*** (0.128)
$\ln(e_{x,t-1}/M_{t-1})$	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)
$\tau_x$	-0.001 (0.004)	-0.003* (0.002)	-0.001 (0.001)	-0.000 (0.001)	0.000 (0.000)	0.000 (0.001)	0.001 (0.002)
Constant	1.103 (8.498)	6.496* (3.082)	1.497 (1.411)	0.937 (1.294)	-0.763 (0.805)	-0.639 (1.532)	-2.169 (2.997)
Observations	18	18	18	18	18	18	18
F-test (p-value)	0.777	0.247	0.677	0.792	0.693	0.973	0.00457
$\frac{\rho}{\gamma}$	-0.0253	2.377	1.474	1.438	0.318	1.083	-1.496

Standard errors in parentheses

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

F-test: equality test for hypothesis 5:  $H_0: \beta_1 = \beta_2$  ( $\rho = \gamma$ )

$\frac{\rho}{\gamma}$ : the relative magnitude of intra- to inter-temporal elasticity.

wages over the later working life, as it drops too steep to be explained by wage change over old ages. Moreover, the age-wage profiles reveal a profound shift towards old age overtime, whereas the age-employment profiles do not. These patterns cast doubt on the explanatory power of ISH, at least for the later part of the life-cycle.

Combining the time-varying NTA age-profiles with other macro-economic variables allows me to estimate age-specific labor supply function that is theoretically consistent with the overlapping generation framework. Unlike traditional macro-economic analysis relying on National Accounts to estimate a single elasticity for all demographic groups, the NTA data structure enables me to estimate an array of quasi life-cycle parameters. This can serve as a new basis for calibrating the overlapping generation models with age-specific elasticities. Some key findings in my econometric analysis are summarized as follows.

1) In the aggregate model, the estimated elasticity of labor supply with respect

to real wage is very close to that of Alogoskoufis (1987) and Lucas and Rapping (1969). The economic magnitude of inter-temporal elasticity of substitution is smaller than intra-temporal elasticity of substitution, but they appear no statistical difference.

2) The age-specific estimates show considerable variation in the short-run labor elasticity with respect to wage as well as the relative magnitude of inter- and intra-temporal elasticities across age groups. This implies that the elasticities estimated in traditional macroeconomic studies, e.g. Alogoskoufis (1987) and Lucas and Rapping (1969), can only reflect the labor supply behavior in a single representative household framework, but not in multi-generation setting, such as OLG.

3) The variation in age-specific estimates further suggests that an array of “quasi” life-cycle parameters are needed in order to calibrate OLG models for the multi-generational economy.

4) The parameter equality test shows that the inter- and intra-temporal elasticities are about the same magnitude for most age groups. This suggests that the two elasticities are equally important governing the labor supply decision over a large span of the working life, at least prior to age 60.

I would like to conclude this paper by mentioning some limitations of this study and potential extensions for future research. The patterns shown in terms of real wage and labor supply as well as the relation between the two are in an age-specific period setting; therefore, they shall be more literally interpreted as the working behavior in a quasi life-cycle framework. To better reflect the real life-cycle behavior, synthetic cohort studies are certainly preferable. This, however, is not readily implementable given the current state of the NTA time-series for Sweden and data expansion over a longer time horizon is desirable. This should be placed as one of the core tasks for the future development of the NTA project.

This study stresses the wage impact on labor supply. It, however, ignores the value of outside options, e.g. schooling and retirement. Such options might be particularly important for young and old workers; therefore, one extension of the analysis for future research will be to focus on the rate of return to schooling as well as economic incentives for retirement, and their potential impact on the labor supply decision.

The estimated elasticities in this study are very likely to be different from findings of longitudinal studies using micro data. I shall stress that the choice of the level of

the analysis as well as the type of data depends on the research question and the aim of the study. To examine detailed heterogeneity among individuals, micro-level analysis would certainly be preferred. Nonetheless, to apply the individual elasticities to macro models, such as OLG-CGE, one has to ensure the equivalence of the parameters in the two environments implied by the aggregation theory (Browning et al., 1999; Prescott and Wallenius, 2011). For one of the purposes of this paper, that is providing some additional insights to the calibration of OLG models, my estimates are appropriate as they correspond to the average of each representative generation.

## References

- Alogoskoufis, G. S. (1987, Oct). On Intertemporal Substitution and Aggregate Labor Supply. *Journal of Political Economy* 95(5), 938–960.
- Auerbach, A. and L. Kotlikoff (1987). *Dynamic Fiscal Policy*. Cambridge University Press.
- Barro, R. J. (1974). Are Government Bonds Net Wealth? *Journal of Political Economy* 82(6), 1095–1117.
- Bengtsson, T. and K. Scott (2011). Population Ageing and the Future of the Swedish Welfare State. *Population and Development Review* 37, Supplement.
- Börsch-Supan, A. (2003). Labor Market Effects of Population Aging. *Labour Special Issue*, 5–44.
- Browning, M., L. P. Hansen, and J. J. Heckman (1999). Chapter 8 Micro Data and General Equilibrium Models. Volume 1, Part A of *Handbook of Macroeconomics*, pp. 543 – 633. Elsevier.
- Cain, G. (1966). *Married Women in the Labor Force: An Economic Analysis*. Chicago: The University of Chicago Press.
- Calvo, G. (1979). Quasi-Walrasian Theories of Unemployment. *American Economic Review Proceedings* 69, 102–07.
- Coleman, T. (1984). *Essays on Aggregate Labor Market Business Cycle Fluctuations*. Ph. D. thesis, University of Chicago.

- Diamond, P. (1965). National Debt in a Neoclassical Growth Model. *The American Economic Review*.
- Fair, R. (1971). Labor Force Participation, Wage Rates, and Money Illusion. *Review of Economics and Statistics* 53, 164–68.
- Harris, M. and H. Bengt (1982). A Theory of Wage Dynamics. *Review of Economic Studies* 49, 316–33.
- Heckman, J. J. (1993, May). What Has Been Learned about Labor Supply in the Past Twenty Years? *The American Economic Review* 83(2), 116–121.
- Lazear, E. (1981). Agency, Earnings Profiles, Productivity, and Hours Restrictions. *American Economic Review* 71, 606–20.
- Lee, R. and L. Carter (1992). Modeling and Forecasting U.S. Mortality. *Journal of the American Statistical Association* 87(419), 659–671.
- Lee, R. and R. D. Edwards (2001). The Fiscal Impact of Population Change. In *Seismic Shifts: The Economic Impact of Demographic Change*, Number 46, Boston, pp. 190–219. Federal Reserve Bank of Boston conference Series.
- Lee, R., D. Gretchen, and T. Miller (2011). The Changing Shape of the Economic Life-cycle in the United States, 1960 to 2003. In R. Lee and A. Mason (Eds.), *Population Aging and The Generational Economy, A Global Perspective*, Chapter 15, pp. 313–326. Edward Elgar Publishing Limited.
- Lee, S. and N. Ogawa (2011). Labor Income over the Lifecycle. In R. Lee and A. Mason (Eds.), *Population Aging and The Generational Economy, A Global Perspective*, Chapter 5, pp. 109–135. Edward Elgar Publishing Limited.
- Lucas, R. and L. Rapping (1969). Real Wages, Employment, and Inflation. *Journal of Political Economy* 77(5), 721–754.
- Macurdy, T. E. (1981). An Empirical Model of Labor Supply in a Life-Cycle Setting. *Journal of Political Economy* 89(6), 1059–85.
- Mankiw, G. N., J. Rotemberg, and L. Summers (1985). Intertemporal Substitution in Macroeconomics. *Quarterly Journal of Economics* 100, 225–51.
- Miles, D. (1999, Jan). Modelling the Impact of Demographic Change upon the Economy. *The Economic Journal* 109(452), 1–36.

- Mincer, J. (1962). Labor Force Participation of Married Women. In U.-N. Bureau (Ed.), *Aspects of Labor Economics*, pp. 63–106. Princeton: Princeton University Press.
- Modigliani, F. (1986). Life Cycle, Individual Thrift, and the Wealth of Nations. *The American Economic Review* 76(3), pp. 297–313.
- OECD (2011). OECD Employment Outlook 2011. *Directorate for Employment, Labour and Social Affairs*.
- Oppen, J. and J. Vaupel (2002). Broken Limits to Life Expectancy. *Science*, 1029–1031.
- Pissarides, C. (1989). Unemployment Consequences of An Aging Population: An Application of Insider-Outsider Theory. *European Economic Review* 33, 355–366.
- Prescott, E. C. and J. Wallenius (2011). *Aggregate Labor Supply*. Federal Reserve Bank of Minneapolis.
- Samuelson, P. (1958). An Exact Consumption Loan Model of Interest with or without the Social Contrivance of Money. *Journal of Political Economy*.
- Skirbekk, V. (2003). *Age and Individual Productivity: A Literature Survey*. MPIDR.
- Yellen, J. (1984). Efficiency Wage Models of Unemployment. *The American Economic Review* 74(2), 200–205.



## Chapter III







## Chapter 3

# Retirement Behavior of Swedish Notch Babies

This paper received the Gunther Beyer Award for the best paper presented by a young scholar at the European Population Conference 2014. The award was sponsored by the European Association for Population Studies (EAPS).

# Abstract

The 1994 Swedish pension reform introduced cohort differentials in benefit accounting. Those born in 1938 were the first recipients whose benefits were partially computed by the Notional Defined Contribution scheme, therefore known as the “Swedish Notch Babies”. This paper examines the differences in retirement behavior, mainly the pecuniary preference, between the 1937 cohort and the Notch Babies. Results, based on the Survey of Health, Ageing and Retirement in Europe (SHARELIFE), show little differences in the pecuniary preference for retirement. This implies that the observed increase in retirement age among those affected by the 1994 pension reform may be driven by changes in other factors, such as cross-cohort variation in wage, pensions, population structure, and/or non-pecuniary preferences for retirement.

JEL Classification: H31, H55, J26

Keywords: Dynamic Programming, Hierarchical Bayesian Estimation, Pension Reform, Retirement Behavior, Required Rate of Replacement

## 1 Introduction

The term “Notch babies” was originally assigned to birth cohorts that were adversely affected by 1977 amendments to the U.S. Social Security Act. These amendments abruptly lowered the prospective retirement benefits for those born between 1917-21, while leaving older cohorts unaffected (Krueger and Pischke, 1992). This differential is called a “notch”, which also occurred in Sweden during the 1994 Pension Reform which left those born in 1937 or earlier unaffected. The 1938 cohort was the first for whom benefits were computed according to the new rules; therefore, they became the notch generation of the 1994 Swedish Pension Reform, the “Swedish Notch Babies”.

The mean retirement age across many OECD countries followed a downward trend until the early 2000s (OECD, 2013). It has been widely believed that this downward trend during the second half of the 20th century, particularly for men, may be due to the establishment of generous pension systems in most developed countries. If such a causal link holds, one might expect a trend reversal should the

system becomes less generous; however, empirical literature has provided mixed evidence for such a hypothesis.

Labor supply of the U.S. notch babies continued to decline even though their social security benefits were lowered substantially, relative to the older generations after the 1977 amendments to the U.S. Social Security Act (Krueger and Pischke, 1992). OECD statistics, on the other hand, show that average labor market exit age has gradually increased since the early 2000s (OECD, 2013). Some argue that this increase was a result of government interventions in many OECD countries that restricted early retirement schemes and raised statutory retirement ages (Buchholz et al., 2013; Komp et al., 2010). This inconsistent evidence raises the general question of whether the old-age pension system is important for retirement behavior of older workers.

In Sweden, retirement age has displayed a pattern reversal over time, from a trend towards early retirement, to a steady increase in the share of active workers at ages 60+. However, the trend reversal in Sweden occurred earlier (around mid-1990s) than it did in many other OECD countries (around early 2000s). Such a reversal over time has also been observed from a cohort perspective, whereby the mean retirement age exhibited a linear decline for cohorts born between year 1922 and 1937, while the downward trend reversed for those born between 1938 and 1942 (Karlsson and Olsson, 2012).

Some attributed this reversal in Sweden to changes in eligibility rules of disability insurance (DI) that became increasingly stringent during the 1990s (Johansson et al., 2014; Karlström et al., 2008). However, empirical studies specifically evaluating the effect of the 1994 old-age pension reform still remain scarce. Hence, the present study contributes to the literature by looking at the impact of the 1994 Swedish pension reform on retirement behavior. Unlike one earlier study, which estimated a reduced form equation to examine the differences in retirement probabilities across cohorts (Glans, 2008), I focus on the differences in preferences for work-retirement choices between those who were unaffected by the reform and the notch babies.

## 2 A Framework for Thinking about Retirement

The main advancement in retirement studies over the past decades has been due to the collection and exploitation of new data. Prominent data source in the empirical literature include the English Longitudinal Study of Ageing (ELSA), the Health and Retirement Survey in the US (HRS), the Survey of Health, Ageing, Retirement in Europe (SHARE), among others. A more scarce and less exploited data source are administrative data acquired from Income and Tax Registers, such as the Swedish Income Register or Danish Longitudinal Administrative Data. Both types of data have vast potential for studying retirement behavior, but they collect somewhat different information, which leads to different ways of defining retirement.

### 2.1 Defining Retirement

Survey data usually provides an exact age of retirement which is self-reported by interviewees, whereas in register data, the retirement age is commonly defined by the year when labor-related income falls below a certain threshold. Or conversely, the retirement date can also be defined by the time that pension income exceeds a certain threshold. Self-reported retirement age might subject to measurement error, while an income-based definition of retirement may introduce discrepancy between the true and “observed” retirement date. These two methods for defining retirement may potentially lead to different empirical results. Therefore, understanding old-age labor supply as well as retirement behavior demands the exploitation of various types of data.

The current state of empirical literature investigating the effect of pension reform on old-age labor supply and retirement in Sweden are mostly based on large and rich administrative data, e.g. Glans (2008); Johansson et al. (2014); Karlström et al. (2008). Little has addressed this topic by exploiting survey information. Therefore, the present paper complements the previous retirement literature for Sweden based on longitudinal survey data, which reported the exact employment and retirement spells of each individual.

## 2.2 Retirement Function

Analysts usually think of retirement as a discrete choice between working and retiring. The choice is made by maximizing the utility associated with each choice. More explicitly, individuals are assumed to retire if, and only if, the utility of retirement exceeds the utility of working. The general retirement probability can, therefore, be simply defined as:

$$\Pr(R) = \Pr(V_R + \epsilon_R > V_W + \epsilon_W) \quad (3.1)$$

where,  $R$  is the retirement state,  $W$  is the working state,  $V$  is the value, also known as the deterministic part of the utility of either retiring or working.  $\epsilon$  is the unobserved part of utility.

Nearly all retirement studies describe the decision to retire as a generic function written in Eq. (3.1). However, the final specification of retirement models still vary considerably, because researchers tend to specify the value functions ( $V$ ) in Eq. (3.1) in different ways. In general, three types of value functions are commonly derived.

One of the most common retirement models focuses on examining the effects of financial incentives on labor market exits. The value function in this type of model may be implicitly written as:

$$V_p = V(YL, OA, \Omega_p) \quad (3.2)$$

Since financial incentives are mainly related to the income source (e.g. wage ( $YL$ ) and pension ( $OA$ )), the value function, as in (3.2), refers to the pecuniary value of retirement, thereby denoted by  $V_p$ . The last term in (3.2),  $\Omega_p$ , is the parameter set which reflects the preference for wage and pension in the pecuniary value function. Studies which explicitly examined the pecuniary value of retirement have shown that retirement rates spiking at age 65 may be largely explained by the incentives from old-age social security (Gruber and Wise, 1999, 2004; Karlström et al., 2004; Lumsdaine et al., 1992; Stock and Wise, 1990).

Another type of model evaluates the determinants of labor market exit, namely the social, economic, and demographic differences in retirement ages or rates. The value of retirement in this type of model is simply a function of individual characteristics ( $POP$ ) and a set of parameters ( $\Omega_n$ ). The value function may be implicitly written as:

$$V_n = V(POP, \Omega_n) \quad (3.3)$$

Studies which specified the retirement function as in (3.3) can be found in Börsch-Supan et al. (2009); Buchholz et al. (2013); Glans (2008); Klevmarken (2010); Komp et al. (2010); Larsen and Pedersen (2013); Stenberg and Westerlund (2013), which have documented the importance of education, health, occupation, marital status, and/or gender on departure rates from the labor market.

The third type of retirement model combines both economic incentives and social economic differences, such as the models derived and estimated by Berkovec and Stern (1991); Heyma (2004); Johansson et al. (2014). The value function in this type of model is then the combination of  $V_p$  and  $V_n$ , which may be implicitly written as:

$$V_{pn} = V_p(YL, OA, \Omega_p, POP, \Omega_n) \quad (3.4)$$

From (3.4), it is evident that the likelihood of retirement is potentially determined by all the elements in both pecuniary and non-pecuniary value functions. Hence, the probability of retiring may be re-written as:

$$\Pr(R) = f(V_R, V_W, \epsilon) = f(V_{pn}, \epsilon) = f(YL, OA, \Omega_p, POP, \Omega_n, \epsilon) \quad (3.5)$$

The observed changing retirement ages over time and cohorts in Sweden, as we mentioned in the introduction, are usually calculated based on the retirement probabilities. Therefore the cross-time and -cohort variation in retirement age may arise from any of the changes in the elements in (3.5).

Among the retirement literature for Sweden, the only study which examined the effects of the 1994 Swedish pension reform was Glans (2008). In his study, the retirement probabilities were written as a function of  $V_n$ , and therefore, as a reduced-form estimation of  $\Omega_n$ . The present study, however, contributes to the literature by examining the preference change in the pecuniary value of retirement over the 1994 pension reform, which has seldom been evaluated in empirical studies. More explicitly, this study quantifies the difference in  $\Omega_p$  in (3.5) between the cohort who were unaffected by the reform and the notch babies who were affected.

### 3 A Brief History of the Swedish Pension System

The first Swedish pension system was introduced in 1913. It was triggered by the failure of private inter-generational transfers during the industrialization era in

Sweden. During that period, the share of the population engaged in industry, trade and communication increased dramatically, while the share working in the agricultural sector decreased considerably. These structural changes caused a large scale of labor to migrate from the countryside to towns. This left the remaining rural old dependants without support, and thus the parliament established a general old age insurance plan. The 1913 pension was the first in the world to cover all citizens regardless of occupation (Palme and Svensson, 1999). However, this pension had a minor economic impact on individuals, as the benefits were approximately 11 percent of the earnings of a factory worker, merely a third of the subsistence minimum (Bengtsson and Fridlitzius, 1994). By 1930, the replacement rate was still lower than 20 percent (Kruse, 2010).

The Defined-Benefit Pay-As-You-Go system (ATP) was introduced in 1960, which supplemented the flat rate basic pension, thus the pension benefit started to grow. However, pension rights were indexed by prices instead of wage rates, which made the system sensitive to changes in productivity growth (Konberg et al., 2006). Over the 1970s, the real wage fell, yet benefits for retirees remained unchanged. Meanwhile, the old-age dependency ratio started to increase, leading to considerable demographic pressure on the pension system. The pressure was fortunately offset by the rapid economic growth at the time. Such non-responsiveness of the system to economic and demographic changes led to a perverse redistribution of wealth across generations. As a result, nearly half of the bank savings in the 1990s were owned by those aged 65 years or older (Bengtsson and Fridlitzius, 1994).

Furthermore, the benefit accounting in the ATP is weakly connected to pension contribution history. The formula typically redistributes income from low-income to high-income workers, and treats workers with equivalent lifetime earnings, but inequivalent life-cycle earning profiles, unequally (Laun and Wallenius, 2015). It also distorts the labor market by reducing labor force participation and weakening incentives to save (Konberg et al., 2006). A deep recession in the 1990s caused the contribution base to shrink by around 10 percent, which stimulated the need for pension reform. Consequently, in June 1994, the Swedish parliament passed legislation and replaced ATP with a new system that comprised three main pillars. The first pillar is Notional Defined-Contribution Pay-As-You-Go (NDC PAYG or Income Pension) and the second pillar is funded with privately managed individual accounts (Premium Pension). The third pillar is the guaranteed part which is payable from age 65 onward for persons with low lifetime earnings (Palmer, 2000; Hagen, 2013).

A transition rule was applied to gradually switch from ATP to NDC. The 1938 cohort were the first pension recipients to have their benefits calculated under the transition rule; one-fifth under ATP and four-fifths under NDC. Therefore, the 1938 cohort became the first notch babies in the 1994 old-age pension reform in Sweden. The transition rule increased proportion of pension under NDC by 5 percent for each successive cohort up to those born in 1953. From the 1954 cohort onwards, benefits were accounted by a complete conversion of the accumulated pension credits from the old system into the new system (Palmer, 2000; Settergren, 2001; Konberg et al., 2006). Benefits will be completely paid out from NDC by year 2040 (Sunden, 2006).

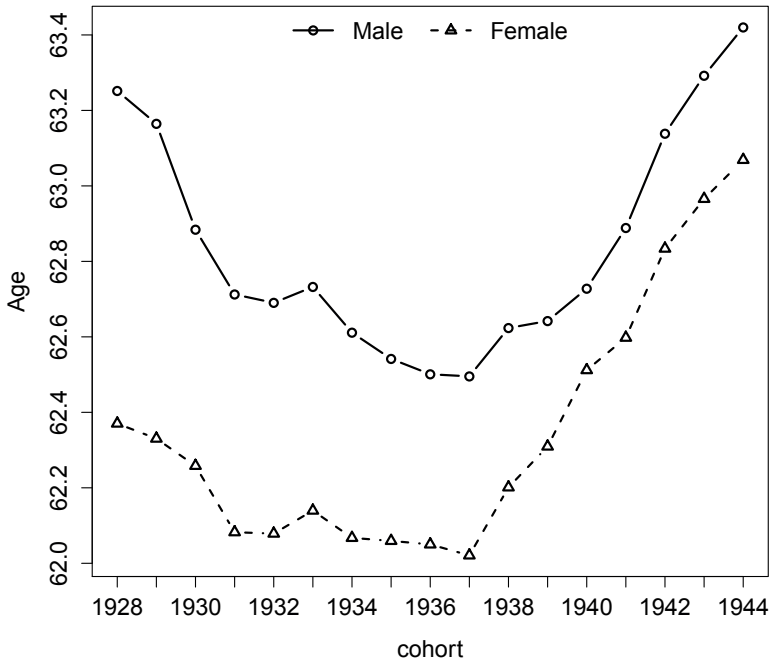
The benefit accounting under NDC and ATP differ in two ways. First, NDC calculates benefits based on the earning history over the entire working life, whereas ATP calculates entitlements based on the best-15-years of earnings. The key implication of this difference is that NDC creates stronger incentives for workers to delay retirement. This is because workers' highest earning years typically occurred prior to age 50, and given the best-15-year rule in ATP, workers would not expect any increase in expected pension benefits. Alternatively, one's pension benefits would increase if they continued working and contributing towards pension assets in NDC.

Second, NDC introduced a divisor for calculating pension benefits, which is an increasing function of remaining life expectancy. This means benefits are reduced for those born in 1938 or later (upon participating in the NDC system) because life expectancy is assumed to continually increase for younger generations (Hagen, 2013). This design also creates incentives for postponing retirement, as one more year of working would give an additional year of pension contribution, but also reduce one year of remaining life expectancy from the divisor. Thus, in short, the pension income was a very flat function of age under ATP, whereas it became increasingly steep under NDC (Laun and Wallenius, 2015; Palmer, 2000). This means that delaying retirement from age 65 to 66 increases pension benefits roughly 9%, and delaying retirement to 67 would increase benefits about 20% (Konberg et al., 2006).

Having summarized the difference in benefit accounting between ATP and NDC, one might expect that the retirement age would increase among those born in 1938 or later as they are more attached to the NDC than the 1937 cohort, who were unaffected by the reform. Indeed, as shown in Figure 3.1, the mean retirement



age increased from the 1938 cohort onwards for both men and women. As can be seen from (3.5), however, the changing benefit may be only one explanation for changing retirement rates. Such inter-cohort variation in retirement age might also arise from differences in other elements in (3.5) between cohorts. Therefore, this paper complements the existing retirement literature for Sweden by addressing the question of whether the cohort trend in retirement age is attributable to the preference change in the pecuniary value of retirement, i.e.  $\Omega_p$  in (3.5).



**Figure 3.1:** Mean age at retirement by cohort, conditioning on population who are still in the labor force at age 50.

Data Source: Swedish Inter-disciplinary Panel (SIP).

Note: Retirement is defined if the worker has no labor income during a calendar year.

## 4 The Retirement Model

Retirement behavior has been a major concern for both economists and politicians in recent decades, due to the ongoing process of population ageing in many developed and developing countries. Several retirement models have been developed by scholars, ranging from static to dynamic, as well as from structural to non-structural. Earlier studies have shown that dynamic models better represent the forward looking behavior of individual workers, and have stronger predictive power compared to static models (Berkovec and Stern, 1991; Heyma, 2004; Lumsdaine et al., 1992; Stock and Wise, 1990).

Some have also argued that structural models are less restrictive than non-structural models. This is because non-structural dynamic models (e.g. Heckman and Macurdy (1980); Macurdy (1981)) assumed that wage schedules over the life-cycle for each individual are fixed, and independent of participation (i.e. a year increase of working experience would have no effect on wage). Structural models, on the other hand, incorporate various effects on wage development, such as age, experience, uncertainty, as well as “job match”, and therefore relax the assumption of fixed pay schedules over the life-cycle (Berkovec and Stern, 1991; Hurd, 1990; Lazear, 1986). In this regard, the retirement model in this paper is not only dynamic, but also structural in the sense that the anticipated wage schedules are conditional on individuals’ previous participation decisions (i.e. years of work experience). The structure of the retirement model is succinctly stated below.

The model assumes that each agent confronts a choice between retiring or continuing to work at each period. The job episodes for each agent are modelled over a finite horizon and discrete time. Individual preferences are assumed to be represented by a constant relative risk aversion utility function (CRRA), in which utility is derived from consumption. Thus the utility function can be written as:

$$U(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma} \quad (3.6)$$

where,  $\gamma$  is a risk aversion parameter and  $c_t$  is the consumption of goods and services.

Assuming consumption is financed through labor income if working, or pension income if retired, the consumption variable in Eq. (3.6) can be replaced by  $y_t$  and  $b_t$  for working and retiring, respectively. Hence, the utility function in Eq. (3.6)

can then be re-written as:

$$U(y_t) = \frac{(y_t)^{1-\gamma}}{1-\gamma} \quad (3.7)$$

$$U(b_t) = \frac{(\alpha b_t)^{1-\gamma}}{1-\gamma} \quad (3.8)$$

where,  $\alpha$  is the utility weight attached to retirement benefit while not working relative to the utility weight attached to labor income while working.

The presence of  $\alpha$  in Eq. (3.8) is inspired by Lumsdaine et al. (1992); Stock and Wise (1990). This parameter is to recognize the difference between the utility associated with a dollar of income while working and the utility associated with a dollar of income while retired.

#### 4.1 Static Choice Problem

In the static scenario, individuals are assumed to be myopic. Therefore, in deciding whether to retire or not, only the current utility derived from either current entitled pension or labor earnings is taken into account. In order for a rational agent to retire, a necessary condition is that the utility of retiring is greater than or, at least, equal to the utility of continuing working. This argument implies that the ratio of Eq. (3.8) to Eq. (3.7) is greater than or equal 1. When this ratio strictly equals to 1, it can be interpreted as a special case - the minimum requirement for the retirement transition to occur. That is to say that the utility derived from pension benefit is no different than that derived from labor income. This minimum requirement condition can be derived by setting the ratio of Eq. (3.8) to Eq. (3.7) to 1, that is:

$$\left\{ \alpha \frac{(b_t)}{(y_t)} \right\}^{1-\gamma} = 1 \quad (3.9)$$

The term  $b_t/y_t$  in Eq. (3.9) is essentially the replacement rate, which is known as an indicator for the level of retirement income relative to labor earnings. Taking the power of  $1/(1-\gamma)$  on both sides of Eq. (3.9) yields a relation between the replacement rate and the parameter  $\alpha$ . Since Eq. (3.9) refers to the minimum requirement for retirement, the term  $b_t/y_t$  can then be interpreted as the required rate of replacement for retirement and denoted by  $R^*$ , which may be expressed as:

$$R^* = \frac{1}{\alpha} \quad (3.10)$$

The interpretation of  $R^*$  is straightforward. When  $\alpha$  equals 1,  $R^*$  will also be 1, implying that an individual would require an amount of pension benefits equal to labor income, in order to retire. Should  $\alpha < 1$ , workers would require retirement income that is  $R^*$  times greater than the current wage. And if  $\alpha > 1$ , the required pension is  $R^*$  percent of labor earnings. In other words, the greater  $\alpha$  is, the lower  $R^*$  will be, and thereby the stronger the preference for retirement.

For instance, if  $\alpha = 1.5$ , the required rate of replacement will be 0.66, which implies that workers would retire if their pension benefit is at least 66% of expected labor income. Or, alternatively, workers would be willing to forego 34% (at the most) of expected labor earnings for not being in the labor force.

## 4.2 Dynamic Choice Problem

To solve the dynamic problem of either retiring or continuing to work, individuals are assumed to be forward looking. This means both current and future utility flows are taken into account when making retirement decisions. Hence, at each time period  $t$ , every individual confronts a choice set: 1) retire and derive utility from current and future pension benefits, or 2) work and derive utility from labor earnings for the current period, and leave the retirement option open for the next period. Thus, at each period, individuals maximize a value function as:

$$V_t = \max \left\{ U(y_t) + \beta E(V_{t+1}) + \epsilon_{1t}, \sum_t^T \beta^{T-t} U(b_t) + \epsilon_{2t} \right\} \quad (3.11)$$

where,  $\beta$  is a discount factor,  $T$  is life expectancy, and  $E(V_{t+1})$  is the expected option value for the next period.  $\epsilon_{1t}$  and  $\epsilon_{2t}$  are error terms, which are assumed to be identically and independently distributed.

The term  $E(V_{t+1})$  is computationally complex, as it can only be solved numerically. However, following Berkovec and Stern (1991), the analytical solution exists if the  $\epsilon$ 's are assumed to be independently and identically random draws from Gumbel distribution (Type-I extreme value distribution). The dynamic programming of the future expected value can then be solved by backward recursive com-

putation using:

$$E(V_{t+1}) = \tau \left\{ u + \ln \left\{ \exp \left( \frac{U(y_{t+1}) + \beta V_{t+2}}{\tau} \right) + \exp \left( \frac{\sum_{i=1}^T \beta^{T-i+1} U(b_{t+1})}{\tau} \right) \right\} \right\} \quad (3.12)$$

where,  $u$  is an Euler constant and  $\tau$  is the scale parameter of the extreme value distribution.

For Eq. (3.12), the terminal condition is defined as the expected future value at the highest possible age for retirement. I assume the latest retirement age is 70 years old. Hence, for  $t = S = 70$ , the expected value at the terminal condition is computed using:

$$E(V_S) = \tau \left\{ u + \ln \left\{ 1 + \exp \left( \frac{\sum_{s=1}^T \beta^{T-s} U(b_S)}{\tau} \right) \right\} \right\} \quad (3.13)$$

The assumption that  $\epsilon'_t$ s are i.i.d. random draws from the Type-I extreme value distribution gives the closed form solution for computing the probability of working and the probability of retiring. Let  $D_t$  be a choice indicator, which equals 0 if the individual chooses to work and 1 if instead retirement is chosen. The probabilities of working and retiring may, therefore, be written as:

$$\begin{aligned} Pr(D_t = 0) &= Pr \left( U(y_t) + \beta E(V_{t+1}) + \epsilon_{1t} > \sum_t^T \beta^{T-t} U(b_t) + \epsilon_{2t} \right) \\ &= \frac{\exp \left( \frac{U(y_t) + \beta E(V_{t+1})}{\tau} \right)}{\exp \left( \frac{U(y_t) + \beta E(V_{t+1})}{\tau} \right) + \exp \left( \frac{\sum_t^T \beta^{T-t} U(b_t)}{\tau} \right)} \quad (3.14) \end{aligned}$$

$$\begin{aligned}
Pr(D_t = 1) &= Pr \left( U(y_t) + \beta E(V_{t+1}) + \epsilon_{1t} \leq \sum_t^T \beta^{T-t} U(b_t) + \epsilon_{2t} \right) \\
&= \frac{\exp \left( \frac{\sum_t^T \beta^{T-t} U(b_t)}{\tau} \right)}{\exp \left( \frac{U(y_t) + \beta E(V_{t+1})}{\tau} \right) + \exp \left( \frac{\sum_t^T \beta^{T-t} U(b_t)}{\tau} \right)} \quad (3.15)
\end{aligned}$$

The inequality between  $U(y_t) + \beta E(V_{t+1}) + \epsilon_{1t}$  and  $\sum_t^T \beta^{T-t} U(b_t) + \epsilon_{2t}$  in Eq. (3.15) implies that, for a rational individual to retire, the sum of the current and the discounted future utility of pension must be greater than or equal to the sum of the current utility of labor income and the expected option value. Therefore, the minimum requirement condition for the retirement transition is these two terms equal to each other. This condition is no different than that in the static scenario discussed previously. Hence, the interpretation for  $R^*$  remains the same.

## 5 Data

The analysis in this paper relies on data from the working life histories in the Survey of Health, Ageing and Retirement in Europe (SHARELIFE), which provides information on different episodes over the entire life course for each observed person, such as years in education, spells of working, unemployment, retirement, etc. The dataset was structured as a panel with information collected through retrospective surveys. The Swedish sub-sample of SHARELIFE contains 1893 individuals, of which 848 are men and 1045 are women. Ideally, all the cohorts should be used for the analysis so that the retirement behavior for those born in 1937 or earlier

can be compared with the notch babies (i.e. those born in 1938 or later). However two concerns arise.

First, during the 1990s, there were two major reforms pertaining to disability insurance (DI). The first reform abolished the utilization of DI for labor market reasons in 1991, and the second reform eliminated the favorable rules of DI admission for workers aged 60-64 in 1997. The latter reform was implemented on January 1, 1997, thus the last group who were still under favorable rules was those born in 1936, who turned 60 years of age prior to January 1, 1997. The first concern of including all cohorts born before 1937 is that it might confound the impact of DI and old-age pension reform. Therefore, to isolate the effect of DI reform from the 1994 old-age pension reform, I exclude all cohorts born before 1937. The 1937 cohort is identical to all later born in terms of DI eligibility rules, but they were not affected by the 1994 reform, and therefore become an ideal reference group.

Second, the retrospective yearly information on whether individuals were working or retired end by 2008/09 in SHARELIFE. As discussed in the proceeding section, the terminal condition for the backward recursive computation of the expected value function is assumed to be at age 70, thus those born after year 1938 have to be excluded from the sample. Doing so assures the same length of exposure to retirement risk (i.e. age span 60-70) across cohorts. Hence, the sample is restricted to those born in 1937 and 1938, of which the older cohort was unaffected by the 1994 pension reform, whereas the younger cohort is the notch babies.

The discrete choices of working or retiring over time for all individuals are the outcome variable in this study. The covariates used are: after-tax monthly wage at the end of main job, after-tax monthly work income at the end of main job, after-tax monthly first pension benefit, gender, year of birth, age, and years in full-time education. Furthermore, SHARELIFE does not provide any health records for each individual over time. However, some health information is obtained by linking the individual in SHARELIFE to the same respondent in the third wave of SHARE, where a self-evaluated general health status variable is available. These variables are discussed in greater detail in the method section. Each individual is assumed to be exposed to the risk of retirement over the age span of 60-70, and once retirement has taken place, the individual is censored from the data. Given this censoring mechanism, the final sample contains 78 individuals and 452 observed person-years.

## 6 Methods

The retirement model formerly stated comprises only two covariates, the labor income if working and benefits if retired. These variables, however, are not available on the yearly basis in SHARELIFE. Therefore the retirement model is estimated by a two-stage-procedure.

In the 1<sup>st</sup> stage, random effects model using Hierarchical Bayesian Estimation is applied to estimate a wage function. The estimation is implemented by Bayesian Inference Using Gibbs Sampling (WinBUGS). The model is stated as:

$$y_i \sim N(\alpha_i, \sigma^2)$$

$$\alpha_i \sim N(\bar{\alpha}_i, \lambda^2)$$

$$\bar{\alpha}_i = \alpha_0 + \alpha_1 age_i + \alpha_2 exper_i + \alpha_3 exper_i^2 + \alpha_4 educ_i + \alpha_5 male_i + \alpha_6 goodhealth_i \quad (3.16)$$

where,  $i$  denotes each individual,  $y$  is labor income,  $\alpha_i$  is the random coefficient for each individual,  $\bar{\alpha}_i$  is the mean of the random coefficient  $\alpha_i$ ,  $\sigma^2$  and  $\lambda^2$  are the variance of observed income across individuals and the variance of the random coefficient  $\alpha_i$ , respectively, which are both assumed to follow inverse gamma distribution, i.e.  $IG(.01, .01)$ , and  $\alpha_0$  to  $\alpha_7$  are the coefficients for all the covariates in the wage equation, which are assumed to be  $N(0, 0.0001)$ .

The data used at this stage is the wage at the end of the main job in SHARELIFE. The sample for the wage estimation is larger than for the retirement estimation, containing 163 individuals born between 1935-40. All wages are in nominal value of local currency, and are therefore converted to 2003 price levels by using the historical price indices 1830-2010 from Statistics Sweden. The other covariates in the wage equation are: age, years of working experience, education level, gender, and health<sup>1</sup>.

The estimated random coefficients in the wage equation, together with the observed information on age, education, experience, gender and health status are

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<sup>1</sup>Years of work experience is the sum of all working spells for each individual, education is a dummy variable (equal to 1 if individual completed 15 years in full-time education, which is equivalent to completing tertiary education, and 0 otherwise), male is a gender dummy (equal to 1 if male, and 0 otherwise), good health is a dummy for self-reported general health status (equal to 1 if it is excellent, very good or good, 0 if fair or poor)



then used to impute the individual labor income streams over the age span of 60-70. The model is structural in the sense that the expected wage growth curve for workers will be dependent not only on age, but also conditional on the past history of work participation (i.e. years of work experience).

SHARELIFE collected information on the first monthly after-tax pension benefit at the nominal values of local currency at time. These values are converted to the 2003 price level following the same procedure as labor income. However, the entitled benefits are assumed to be constant over the ages between 60 and 70. That is to say that the model only allows for cross-individual variation in pension income, and the individual-specific variation is held constant over time.

In the 2<sup>nd</sup> stage, a multinomial logit model is applied to fit the individual discrete choices of working or retiring using Hierarchical Bayesian Estimation (HB). The main reason to apply HB estimation other than the Maximum Simulated Likelihood (MSL) is that the sample size is small, merely 78 individuals. This might lead to the case of asymptotic properties not being fully exhibited. As argued by Train (2009), unlike the classical perspective requiring the asymptotic assumption of the sampling distribution, which might not be fulfilled when the sample size is insufficient, the posterior distribution in the Bayesian approach contains the information with any sample size, and is therefore suitable for small sample inference. The HB estimation procedure is stated as follows. From Eq. (3.14) and Eq. (3.15), the likelihood function can be written as:

$$\begin{aligned}
L(D_{i,t} \mid \gamma_i, \alpha_i, \beta_i) = & \prod_t \left\{ \frac{\exp\left(\frac{U(y_{i,t}) + \beta E(V_{i,t+1})}{\tau}\right)}{\exp\left(\frac{U(y_{i,t}) + \beta E(V_{i,t+1})}{\tau}\right) + \exp\left(\frac{\sum_t^T \beta^{T-t} U(b_{i,t})}{\tau}\right)} \right\}^{1-D_{i,t}} \\
& \times \left\{ \frac{\exp\left(\frac{\sum_t^T \beta^{T-t} U(b_{i,t})}{\tau}\right)}{\exp\left(\frac{U(y_{i,t}) + \beta E(V_{i,t+1})}{\tau}\right) + \exp\left(\frac{\sum_t^T \beta^{T-t} U(b_{i,t})}{\tau}\right)} \right\}^{D_{i,t}}
\end{aligned} \tag{3.17}$$

Let  $\theta_i$  be a vector of individual random parameters  $\gamma_i, \alpha_i, \beta_i \forall i$  and  $\theta_i \sim N(\Theta, W)$ , where,  $\Theta$  is the vector of population level parameters  $\bar{\gamma}, \bar{\alpha}, \bar{\beta}$  and  $W$  is the variance-covariance matrix for the population level parameters. The prior is thereby  $p(\Theta, W) = p(\Theta)p(W)$ , where,  $p(\Theta) \sim N(\Theta_0, S_0)$  with extremely large variance,  $p(W) \sim IW(3, I)$ , which is Inverse Wishart Distribution with 3 degree of freedom and a 3-dimensional identity matrix. The three conditional posteriors are therefore written as:

$$\mathbf{P}(\Theta \mid W, \theta_i \forall i) \sim N(\bar{\theta}, W/N) \tag{3.18}$$

where,  $N$  is number of observed individuals, and  $\bar{\theta} = \sum_{i=1}^N \frac{\theta_i}{N}$

$$\mathbf{P}(\mathbf{W} \mid \Theta, \theta_i \forall i) \sim IW\left(3 + N, \frac{3 \times \mathbf{I} + N \times \bar{\mathbf{S}}}{3 + N}\right) \quad (3.19)$$

$$\text{where, } \bar{\mathbf{S}} = \sum_{i=1}^N \frac{(\theta_i - \Theta)(\theta_i - \Theta)'}{N}$$

$$\mathbf{P}(\theta_i \mid \Theta, \mathbf{W}, D_{i,t}) \propto \prod_t L(D_{i,t} \mid \gamma_i, \alpha_i, \beta_i) \phi(\theta_i \mid \Theta, \mathbf{W}) \forall i \quad (3.20)$$

where,  $\phi(\theta_i \mid \Theta, \mathbf{W})$  is the normal density of  $\theta_i$ 's conditional on hyper-parameters  $\Theta$  and  $\mathbf{W}$ .

All the parameter estimates are obtained from the above three conditional posteriors by Gibbs Sampler. Eq. (3.18) and Eq. (3.19) give the hyper-parameters and their corresponding variance-covariance, and Eq. (3.20) provides the individual parameters for each  $i$ . For both static and dynamic models, the number of iterations for Monte Carlo Markov Chain is set to 40000, of which the first 20000 iterations are burn-in.

## 7 Results and Discussion

### 7.1 Wage Estimation and Imputation

Table 3.1 reports the parameter estimates for the wage equation (3.16) using Hierarchical Bayesian Estimation. The wage rates are transformed into logarithm scale. The estimated coefficients suggest that wages drop at a rate of 2% per year between age 60 and 70. Completing tertiary education (year of schooling greater than or equal to 15) leads to a 12.5% wage premium. Men earn 30% higher than women, whereas workers with good health receive about a 7% higher wage than those with poor health.

The estimated coefficients in Table 3.1 are then used for imputing the expected wage stream for each individual over ages 60-70. For each individual,  $\bar{\alpha}_i$  is first obtained by calibrating the parameters in Table 3.1 to Eq. (3.16). Then the impu-

tation proceeds by evaluating the two integrals:

$$\begin{aligned} E[\alpha_i] &= \int \bar{\alpha}_i \phi(\bar{\alpha}_i, \lambda^2) d\bar{\alpha}_i \\ E[y_i] &= \int E[\alpha_i] \phi(E[\alpha_i], \sigma^2) dE[\alpha_i] \end{aligned} \quad (3.21)$$

Both integrals in Eq. (3.21) are approximated by taking the means of 10000 draws for  $\alpha_i$  and  $y_i$  from the two corresponding normal density  $\phi(\bar{\alpha}_i, \lambda^2)$  and  $\phi(E[\alpha_i], \sigma^2)$ .

**Table 3.1:** Estimation of Wage Equation Eq. (3.16)

	Coef.
Constant	10.577 (1.605)
Age	-0.021 (0.018)
Experience	0.138 (0.050)
Experience <sup>2</sup>	-0.002 (0.001)
Education	0.125 (0.080)
Male	0.313 (0.070)
Good Health	0.073 (0.075)
$\lambda^2$	0.267 (0.098)
$\sigma^2$	0.264 (0.099)
Observations	163
Chains	3
Iterations	20000

Note: Standard errors in parentheses.

## 7.2 Population-level Parameter Estimates

Table 3.2 reports the population-level parameters and their standard errors estimated by Eq. (3.18) and Eq. (3.19). As SHARELIFE does not provide information on savings/wealth, the effect of asset change on consumption growth can not be identified. To deal with this, the risk aversion parameter,  $\gamma$  in Eq. (3.6), is imposed as zero in the empirical estimation of the retirement model. In other words, the form of utility function specified in Eq. (3.7) and (3.8) is simply reduced to a linear function of income. Both static and dynamic models are estimated. The former only provides the estimates of  $\alpha$ , and the latter estimates an additional parameter, the discounting factor.

**Table 3.2:** Population Level Parameter Estimates of the Retirement Model

	Static Coef.	Dynamic Coef.
$\gamma$	0 <sup>a</sup>	0 <sup>a</sup>
$\alpha$	1.105 (0.309)	1.307 (0.246)
$\beta$		0.342 (0.217)
Observed Individuals	78	78
Observed Person-years	452	452
Iterations	40000	40000
Burn-in's	20000	20000
Log-likelihood	-199.83	-203.08

<sup>a</sup> Parameter value imposed.

Note: Standard errors in parentheses.

It is important to stress that the coefficients and standard errors reported in Table 3.2 are the means of each element in  $\Theta$  in Eq. (3.18) and on the diagonal of  $W$  in Eq. (3.19) over the last 20000 iterations<sup>2</sup>. Hence, the interpretation of these estimates is no different than the point estimates and standard errors in the standard maximum

<sup>2</sup>The standard errors are computed by taking the square root of the diagonal of the variance-covariance matrix,  $W$ .

likelihood estimation. Nevertheless, this does not necessarily imply that the value of the posterior mean would be identical to the point estimates in the maximum likelihood estimation, because they could differ if, for example, the sample size is insufficient for the asymptotic convergence (Train, 2009).

The estimated discounting factor  $\beta$  is 0.34 suggesting that, on average, individuals weigh future utility merely a third of current utility when deciding whether to retire today. One explanation for such a low estimate is that individuals at older ages might become myopic, and thus regard the current utility of income more important than its future value.

The  $\alpha$  coefficient estimated by the dynamic model is greater than the same coefficient estimated by the static model. When the future utility flows are not taken into account, the utility weight on non-labor income is over 10% higher than on income from work. However, when future utility flows are incorporated in the retirement model, the same amount of income from pensions would give 30% greater utility than would income from labor.

Using Eq. (3.10), the required rate of replacement,  $R^*$ , is 0.91 in the static model and 0.77 in the dynamic model. This can be interpreted as workers would retire if their pension benefits were at least 91% (based on the static model) and 77% (based on the dynamic model) of expected labor income. Or equivalently, workers would be willing to forego 9-23% (at the most) of labor income in order to exit the labor market.

One reason why  $R^*$  is different between the static and the dynamic model is that the value of retirement at each age is weighted by the future utility flows in the dynamic setting, whereas it is only weighted by the current utility flows in the static setting. The future utility of retirement is an increasing function of age because workers would increasingly prefer to retire when they grow older. Given that both labor and pension income profiles are the same across the two models, the dynamic model captures more utility flows at older ages than does the static model, and therefore the value of retirement relative to the value of working is expected to be higher in the dynamic setting. As a result, the estimated  $\alpha$  in the dynamic model is larger (or equivalently,  $R^*$  is smaller) than in the static model.

The extent to which  $\alpha$  or  $R^*$  differs between the static and dynamic model is dependent on the discounting factor  $\beta$ . If  $\beta$  is zero, all future utility becomes irrelevant, thus the static and dynamic model are identical, and  $\alpha$  and  $R^*$  will be the same

across models. If  $\beta$  is non-zero,  $\alpha$  and  $R^*$  will then differ between the static and dynamic estimations, and the larger the discounting factor is, the more influence future utility flows will have on the current value of retirement. As just discussed, the current value of retirement relative to working is expected to be higher in the dynamic model than in the static one, therefore the greater the discounting factor is, the lower the  $R^*$  will be (or the higher  $\alpha$  will be). This explains why  $R^*$  estimated by the dynamic model is 14% lower, given the discounting factor being 0.34 and other factors being equal.

### 7.3 Cohort Differences in Retirement Preference

As stated in the beginning of the paper, the main purpose of this study is to complement the retirement literature for Sweden by examining the difference in retirement preferences between the cohort unaffected by the 1994 old-age pension reform and the notch babies. For this purpose, I further examine the heterogeneity of  $R_i^*$  across cohorts. This exercise compares the mean of the individual-level parameter estimates of  $R_i^*$  for the 1937 cohort with the notch babies, the results of which are reported in the first row in Table 3.3.

**Table 3.3:** Summary of Individual-level  $R_i^*$  by Cohort

Cohort	Static		Dynamic	
	1937	1938	1937	1938
Mean	0.967	0.969	0.861	0.840
Median	0.827	0.818	0.714	0.702

Similar to the population-level estimates, the means of  $R_i^*$  are about 10% lower in the dynamic model than in the static model for both cohorts. Overall, the cohort differences in the required rate of replacement are small, with no variation in the mean  $R_i^*$  across the two cohorts in the static model, while  $R_i^*$  is 2% lower on average for the notch babies in the dynamic model, implying that those affected by the reform had a stronger pecuniary preference for retirement than those unaffected. This somewhat contradicts the cohort trend of mean retirement age shown in Figure 3.1, whereby the notch babies retired slightly later than the 1937 cohort. Such empirical evidence suggests that the observed cross-cohort variation in mean retirement age is unrelated to cohort differences in the pecuniary preference for re-

tirement, i.e.  $\Omega_p$  in (3.5). Hence, the potential factors responsible for the reversing cohort trend of retirement age may be the variation in wage, pension, population structure, and/or non-pecuniary preferences for retirement across cohorts.

The second row in Table 3.3 reports the medians of the required rate of replacement for the two cohorts, respectively. The between-cohort difference is, once again, negligible. Based on the dynamic estimation, half of the near-retirement aged population are willing to forego about 30% of the expected labor income to retire.

## 8 Conclusion

Sweden, along with many other OECD countries, underwent several pension reforms during the 1990s. To date, retirement studies for Sweden have mainly focused on the effects of changing eligibility rules of disability insurance on labor market exit behavior, while the 1994 old-age pension reform has been studied to a much less extent. Hence, the present study pays particular attention to the difference in retirement behavior between those who were unaffected by the 1994 reform and the notch babies, who were affected.

Furthermore, the only study investigating the effect of the 1994 Swedish pension reform on retirement behavior is Glans (2008), which relied on a reduced-form estimation of retirement differentials with respect to social, economic, and demographic strata using administrative data. The current study, however, complements the literature in two ways. First, my analysis is based on survey data, in which, the exact retirement spells are reported. This differs from the retirement status defined based on observed income in administrative data, as it provides a more precise date of labor market exit. Second, I stress on the pecuniary value of retirement and examine whether the pension reform altered workers' preference for retirement, an aspect not previously explored.

The retirement model in this study is similar to earlier models developed by Berkovec and Stern (1991); Heyma (2004); Lumsdaine et al. (1992); Stock and Wise (1990). The model is estimated using both a static and dynamic method, to account for the assumption of individuals' forward-looking behavior. The static model assumes individuals are myopic, for which, the discounting factor is set to zero, while the dynamic model represents the perfect foresight assumption, where the discounting factor  $\beta$  is estimated. The estimated discounting factor is low, merely



o.34. This suggests that individuals weigh the current utility much higher than the future utility flows when deciding whether to retire today.

At the population level, the estimates of preference parameters in both dynamic and static models are comparable with the findings in Stock and Wise (1990). At the individual level, the estimated required rate of replacement,  $R^*$ , shows little difference between the 1937 cohort and the notch babies. This finding suggests that the increasing mean retirement age is unlikely to be driven by the changing preference in the pecuniary value function of retirement. It further implies that the reversal in retirement age shown in Figure 3.1 may be driven by changes in any of the other elements in Eq. (3.5), such as changing labor and/or pension income, population characteristics, and/or preferences for non-pecuniary value of retirement.

I would like to conclude this paper by discussing some caveats in the analysis. The results reported in this paper could be biased for a number of reasons. First, the sample size is relatively small and may lead to concerns regarding its representativeness, thus the finding may not be generalizable to the population. Second, the small sample size further prevents the retirement model from including the non-pecuniary value of retirement determined by social, economic, and demographic characteristics. This is likely to lead to biased estimates of the preference parameters, such as  $R^*$ , due to omitted variables. Third, the retrospective survey on life history could potentially introduce measurement error, such as recall bias and/or selection bias. This may lead to a biased measurement of the outcome variable as well as covariates.

The aforementioned caveats are mainly attributable to the nature of the survey data. As a result, it is necessary to conduct a similar analysis using another data source, such as the administrative data in Sweden, to validate the findings in this study. The Swedish register data covers the entire population which may lead to less concern on the representativeness of the sample. Additionally, a larger sample size also gives the potential to control for social, economic, and demographic characteristics. Nevertheless, using register data presents other obstacles, such as defining retirement spells based on observed labor and pension income, which may be misleading. Therefore, empirical studies based on various data sources are absolutely needed, as they may provide us with a complementary understanding of the retirement behavior and its relation to the institutional setting.

## References

- Bengtsson, T. and G. Fridlitzius (1994). Public Intergenerational Transfers as An Old-age Pension Systems: A Historical Interlude? In J. Ermisch and N. Ogawa (Eds.), *The Family, the Market and the State in Ageing Societies*. New York: Oxford University Press Inc.
- Berkovec, J. and S. Stern (1991). Job Exit Behavior of Older Men. *Econometrica* 59(1), 189–210.
- Börsch-Supan, A., A. Brugiavini, and E. Croda (2009). The Role of Institutions and Health in European Patterns of Work and Retirement. *Journal of European Social Policy* 19(4), 341–358.
- Buchholz, S., A. Rinklake, and H. P. Blossfeld (2013). Reversing Early Retirement in Germany A Longitudinal Analysis of the Effects of Recent Pension Reforms on the Timing of the Transition to Retirement and on Pension Incomes. *Comparative Population Studies* 38(4).
- Glans, E. (2008, November). Retirement Patterns during the Swedish Pension Reform. Working Paper Series 2008:9, Uppsala University, Department of Economics.
- Gruber, J. and D. Wise (1999). *Social Security and Retirement around the World*. Chicago, IL: The University of Chicago Press.
- Gruber, J. and D. Wise (2004). *Social Security and Retirement around the World: Micro Estimation of Early Retirement Incentives*. Chicago, IL: The University of Chicago Press.
- Hagen, J. (2013, May). A History of the Swedish Pension System. Working Paper Series, Center for Fiscal Studies 2013:7, Uppsala University, Department of Economics.
- Heckman, J. J. and T. E. Macurdy (1980). A Life Cycle Model of Female Labour Supply. *The Review of Economic Studies* 47(1), pp. 47–74.
- Heyma, A. (2004). A Structural Dynamic Analysis of Retirement Behaviour in the Netherlands. *Journal of Applied Econometrics* 19(6), 739–759.

- Hurd, M. D. (1990). Research on the Elderly: Economic Status, Retirement, and Consumption and Saving. *Journal of Economic Literature* 28(2), pp. 565–637.
- Johansson, P., L. Laun, and M. Palme (2014, May). Pathways to Retirement and the Role of Financial Incentives in Sweden. NBER Working Papers 20123, National Bureau of Economic Research.
- Karlsson, H. and H. Olsson (2012). Medelpensioneringsalder och Uttradesalder 2011.
- Karlström, A., M. Palme, and S. Ingemar (2008). The Employment Effect of Stricter Rules for Eligibility for DI: Evidence from A Natural Experiment in Sweden. *Journal of Public Economics* 92, 2071–2082.
- Karlström, A., M. Palme, and I. Svensson (2004). A Dynamic Programming Approach to Model the Retirement Behaviour of Blue-Collar Workers in Sweden. *Journal of Applied Econometrics* 19(6), 795–807.
- Klevmarken, A. (2010). Vereforms efter 65 års ålder? En statistisk analys. Report från sociala rådet, Statens Offentliga Utredningar.
- Komp, K., T. Tilburg, and M. B. Groenou (2010). Paid Work between Age 60 and 70 Years in Europe: A Matter of Socio-economic Status? *International Journal of Ageing and Later Life*.
- Konberg, B., E. Palmer, and A. Sunden (2006). The NDC Reform in Sweden: the 1994 Legislation to the Present. In R. Holzmann and E. Palmer (Eds.), *Pension Reform: Issues and Prospects for Non-financial Defined Contribution (NDC) Schemes*. Washington D.C.: The World Bank.
- Krueger, A. B. and J.-S. Pischke (1992). The Effect of Social Security on Labor Supply: A Cohort Analysis of the Notch Generation. *Journal of Labor Economics* 10(4), 412–37.
- Kruse, A. (2010). A Stable Pension System: The Eighth Wonder. In T. Bengtsson (Ed.), *Population Ageing - A Threat to the Welfare State?* Springer Berlin Heidelberg.
- Larsen, M. and P. Pedersen (2013). To Work, to Retire, or Both? Labor Market Activity after 60. *IZA Journal of European Labor Studies* 2(1).

- Laun, T. and J. Wallenius (2015, July). A Life Cycle Model of Health and Retirement: the Case of Swedish Pension Reform. *Journal of Public Economics* 127, 127–136.
- Lazear, E. P. (1986). Retirement from the Labor Force. In O. C. Ashenfelter and R. Layard (Eds.), *Handbook of Labor Economics*, Volume 1, Chapter 5, pp. 305–355. Elsevier.
- Lumsdaine, R. L., J. H. Stock, and D. A. Wise (1992). Three Models of Retirement: Computational Complexity versus Predictive Validity. In D. A. Wise (Ed.), *Topics in the Economics of Aging*. University of Chicago Press.
- Macurdy, T. E. (1981). An Empirical Model of Labor Supply in a Life-Cycle Setting. *Journal of Political Economy* 89(6), 1059–85.
- OECD (2013). Pensions at A Glance 2013: OECD and G20 Indicators. *OECD Publishing*.
- Palme, M. and I. Svensson (1999). Social Security, Occupational Pensions, and Retirement in Sweden. In J. Gruber and D. A. Wise (Eds.), *Social Security and Retirement around the World*. University of Chicago Press.
- Palmer, E. (2000). The Swedish Pension Reform Model : Framework and Issues. Discussion Papers no. 23086, The World Bank.
- Settergren, O. (2001). Two Thousand Five Hundred Words on the Swedish Pension Reform. Working Papers no. 2001:1, The National Social Insurance Board.
- Stenberg, A. and O. Westerlund (2013). Education and Retirement: Does University Education at Mid-Age Extend Working Life? *IZA Journal of European Labor Studies* 2(1).
- Stock, J. H. and D. A. Wise (1990). Pensions, the Option Value of Work, and Retirement. *Econometrica* 58(5), 1151–80.
- Sunden, A. (2006). How Much Do People Need to Know about Their Pensions and What Do They Know? In R. Holzmann and E. Palmer (Eds.), *Pension Reform: Issues and Prospects for Non-financial Defined Contribution (NDC) Schemes*. Washington D.C.: The World Bank.
- Train, K. E. (2009). *Discrete Choice Methods with Simulation*. Cambridge University Press.

## Chapter IV





## Chapter 4

# Old-age Employment in Sweden: the Reversing Cohort Trend

*with Jonas Helgertz and Tommy Bengtsson*

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# Abstract

Sweden, like many OECD countries, has witnessed a reversal of old-age labor supply, from a trend toward early retirement to a steady increase in the age at labor market exit. This change is widely believed to be a consequence of pension reforms in the 1990s, which increased the stringency of eligibility for disability insurance, while providing financial incentives for postponing retirement. Previous literature on this topic has paid little attention to the possible impact of population compositional change on the reversing old-age labor supply. This paper examines the role of the variation in population characteristics on the changing old-age employment over time. Decomposition analyses show that population structural change explains little of the reversed old-age labor supply trend among men, but one fourth among women, due mainly to the variation in the share of educated female workers.

JEL Classification: H55, I25, J26

Keywords: Education, Employment, Pensions, Policies, Retirement

## 1 Introduction

The effective labor market exit age declined across most OECD countries for several decades until the early 2000s, before gradually increasing thereafter (OECD, 2013). Some empirical studies have shown that this type of trend reversal might be a result of policy interventions, such as raising statutory retirement age, restricting early retirement schemes, and/or embedding stronger economic incentives in the pension system to delay retirement (Buchholz et al., 2013; Komp et al., 2010).

Sweden, like other OECD nations, experienced a reversal in old-age labor supply, from a trend towards early retirement to a steady growth in the number of active workers aged 60+. This reversal, however, occurred earlier than in other OECD countries. The average exit age for men dropped from around 66 in 1970 to 62 in 1994, and then gradually increased to approximately 64 in 2011, while for women, it gradually increased from roughly 61 in 1980 to 63 in 2011 (Karlsson and Olsson, 2012). Is this increase, at least since the mid-1990s in Sweden for both men and women, a result of policy amendments, particularly the public pension reform in



1994? This is an important question because how older workers respond to such policy changes has implications for future labor supply in an ageing economy; a better understanding of such implications are necessary for assessing the long-term welfare consequences of demographic deficits driven by the process of population ageing.

The relationship between pension and retirement behavior has been extensively investigated in economic literature. One of the most common research findings is that retirement age strongly corresponds to the pension age at which benefits are available, and thus the most important cause of the spiking retirement rate at age 65 is economic incentives embedded in the social security system (Berkovec and Stern, 1991; Gruber and Wise, 1999, 2004; Heyma, 2004; Johansson et al., 2014; Karlström et al., 2004; Lumsdaine et al., 1992; Stock and Wise, 1990). If this causal relation holds, one might argue that the rising mean retirement age in Sweden, as well as in many other OECD nations, might be a result of pension reforms that generally create financial incentives for working longer.

Previous literature also shows important social, economic, and demographic gradients on retirement outcome. For example, the importance of education, health, occupation, marital status, and gender on labor market departure rates has been documented by Börsch-Supan et al. (2009); Buchholz et al. (2013); Glans (2008); Klevmarken (2010); Komp et al. (2010); Larsen and Pedersen (2013); Stenberg and Westerlund (2013). This body of work implies that a possible explanation for the changing retirement age may arise from variation in population composition over time. For example, the aged 60+ population today may be on average healthier, more educated, and/or better skilled than the same-aged cohorts from previous decades, which, given that healthy, educated, and/or skilled workers are more likely to prolong working life, may also lead to increases in the mean retirement age.

This mechanism, however, has been seldom investigated in retirement literature, and therefore motivates the present paper, which examines the importance of population compositional change on later-life employment dynamics. More explicitly, this study decomposes the reversing trend in old-age labor supply into two types of effects; population structural change, and a residual that captures the effects of pension policy amendments, as well as changes in behavior, culture, social norms, and/or labor demand. We are particularly interested in whether developments in education, immigration, and/or health are important in this regard. Our analysis

relies on data from the Swedish Interdisciplinary Panel (SIP), which covers the entire population born between 1930 and 1980, and living in Sweden sometime during the time period 1968-2013.

## **2 Research Background**

### **2.1 Population Ageing and Its Consequences**

Population ageing has been an ongoing process in Sweden over the past century, with the share of the elderly (age 65+) more than doubling during the period between 1900-2000. Conventional wisdom on the causes of population ageing are changing demographic conditions, such as declining mortality and fertility, as formulated by stable population theory (Preston et al., 1989, 2001). While the net effect of fertility decline is clear, that of mortality decline is ambiguous on population ageing; whether it exerts a positive or negative impact depends on changes in the life-cycle survival schedule (the individual ageing effect) and the initial level of mortality (Lee, 1994).

The initial mortality decline in Sweden occurred around mid-19th century, and actually made the population grow younger as the individual ageing effect was outweighed by the rate of population growth effect. Hence, the process of population ageing in Sweden from the late-nineteenth to the late-twentieth century was mainly driven by the fertility decline (Coale, 1957; Bengtsson and Scott, 2011), a so-called “first stage of population ageing”. However, human survival, particularly after age 65, has been continuously increasing over the past decades, propelling further increases in life expectancy. This has made the individual ageing effect dominate the rate of growth effect, which in turn shifted the determinants of population ageing from fertility to mortality decline, a so-called “second stage of population ageing”.

The first stage of population ageing actually exerted a positive effect on economic development and provision of welfare services, as falling fertility, coupled with the reduction in premature death, resulted in a greater number of workers relative to the number of dependants (an increase in the demographic support ratio). This phenomenon is often referred to as “the first demographic dividend” (Bloom and Canning, 2009; Mason, 2005; Mason and Lee, 2007; United Nations, 2013). The second stage of population ageing, however, will lead to rapid growth in the

share of the elderly, and, therefore, a declining support ratio, which may adversely influence the economy and the welfare state. In other words, the “demographic dividend” first created by population ageing is now or will soon be transformed into a “demographic deficit”.

One major economic concern which arises from the demographic deficit is the rising per worker cost of transferring per capita resources to a given age vector of non-workers (i.e. children and elderly), assuming working life duration is fixed between ages 20 and 65 (Lee and Edwards, 2001). Transfers may be mediated by public and/or private institutions. In Sweden, these transfers are entirely funded through public channels (Hallberg et al., 2011; Mason and Lee, 2011; United Nations, 2013), raising the question: can the public finance system be sustained at a level that maintains the standards of living given the demographic deficit?

In addition, the life-cycle consumption pattern in Sweden exhibits a strong tilt towards older ages, roughly doubling for those aged 80 to 100, compared to the working-age population. This pattern is in sharp contrast to the classical pattern implied by the life-cycle hypothesis, whereby consumption stays constant throughout the entire life-cycle (Jappelli and Modigliani, 2005). The sharp increase in old-age consumption in Sweden is strikingly similar to the U.S. pattern, and is mainly driven by health expenditures (Lee et al., 2011). However, the financing of such expenditure is fundamentally different; it is predominately reliant on public transfers in Sweden, whereas paid through private spending in the U.S. Similarly, pension provisions will naturally grow when the share of the population reaching retirement age expands. The pension system in Sweden relies entirely on the public transfer system, placing increased fiscal pressure on Swedish public finances in light of demographic deficits.

## **2.2 Policy Options for Tackling Demographic Deficit**

The looming demographic deficit may be tackled by policy measures. Cutting benefits is one approach, which may however lead to welfare loss. This approach simply shifts responsibility from the public to the private sector, and therefore in no way addresses the problem of demographic deficits. Cutting benefits may also deteriorate overall economic efficiency, as some welfare services are shifted to households forcing family members to leave the labor market. Issuing national debt might be an alternative solution; however, this measure tends to be repaid by

future generations, and thus raises the issue of inter-generational equity. Public debt might also crowd out private capital, which could erode productive investment, unless a Ricardian equivalence proposition holds (Barro, 1974). The recent debt crisis felt throughout Europe may create additional obstacles for further debt issuance.

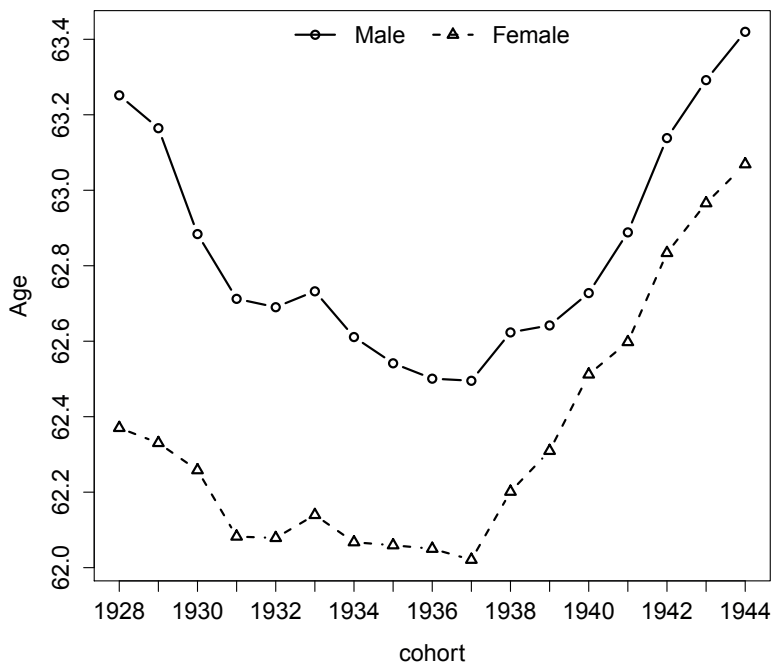
Demographic policies, such as promoting childbearing and migration, might be effective policy measures (Harper, 2014). Rising fertility, however, would take 2-3 decades before newborns age into the labor market and exert a positive effect on the working population, and the number of immigrants needed to offset the declining support ratio will be very large (Bengtsson and Scott, 2011). Additionally, the extent to which immigration might mitigate the demographic deficit further depends on whether foreign workers integrate into the labor market and fill demand. Hence, recent policy discussions put particular emphasis on extending the length of working life, which might be helpful towards expanding the tax base and provide financial support necessary to offset the adverse impact of the demographic deficit.

One of the measures for working life prolongation is to reform the defined benefit pension system. Many governments have committed to such a reform strategy in recent decades, through raising statutory retirement ages, restricting early retirement schemes, and/or creating financial incentives to prolong working life (OECD, 2013). Sweden, without exception, has undergone three major reforms on the pension system during the 1990s. Stringency of eligibility for disability insurance (DI) was raised twice, in 1991 and 1997, respectively (Hagen, 2013). In 1994, the Swedish parliament passed legislation that the former old-age pension system (ATP) would be phased out by a new one - notional defined contribution (NDC).

### **2.3 Institutions and Old-Age Employment**

Although the 1994 pension reform in Sweden was implemented in a specific year, it affected different birth cohorts disproportionately due to some transitional rules embedded in the reform process. Hence, the observed trend reversal in retirement age shall also be visible with a cohort perspective, if the pattern reflects the effect of policy amendments. Indeed, as shown in Figure 4.1, the cohort pattern of mean effective retirement age follows a downward trend up to the 1937 cohort, and dra-

matically increased from the 1938 cohort onwards. Some have argued that such a reversal might be attributable to the 1994 pension reform (Glans, 2008; Karlsson and Olsson, 2012). However, it may also be associated with other reforms, such as changes within the disability pension program from the early 1960s to late 1990s.



**Figure 4.1:** Mean age at retirement by cohort, conditioning on population who are still in the labor force at age 50  
 Data Source: Swedish Inter-disciplinary Panel (SIP).  
 Note: Retirement age defined by the first calendar year with no labor income.

The disability pension system, since the 1963 reform through the early 1990s, can be considered generous, as it was unrestrictive on eligibility and allowed workers to retire for labor market reasons, which explains the downward trend in labor force participation among older workers during this period (Hagen, 2013). One might argue that the downward trend would be reversed, once disability pension became more restrictive on eligibility and less generous. Indeed, Karlström et al.

(2008) have shown that the 1997 DI reform, which abolished the special eligibility rules and prohibited utilizing disability insurance for labor market reasons among those aged 60-64, had a positive impact on older workers' labor force participation rate.

However, Karlström et al. (2008) have also shown that this reform did not instantly increase the de facto employment rate, due to the “communicating vessel effect” (increased utilization of unemployment insurance and sickness benefits). In addition, they argue that the employment effect might take about 2 or 3 years to exert itself, as employees, employers, and unions need time to adjust to the post-reform rules. Unfortunately, the data in their study extended only until 2001, thus further development in old-age employment, as a response to the disability pension reform, remains unclear. Although Karlsson and Olsson (2012) showed that the effective labor market exit age gradually increased up until 2011 since the mid-1990s, it is still difficult to fully attribute such an increase, particularly after 2001, to the disability pension reform, because the 1994 public pension reform was implemented at about the same time.

The major change in the 1994 public pension reform was to replace the Defined-Benefit Pay-As-You-Go system (Allman tillaggpension, hereafter ATP) with the Notional Defined-Contribution Pay-As-You-Go system (hereafter NDC). The former has been proven to be unsustainable given an ageing population, whereas the latter is designed to ensure long-term solvency of the pension system. The key difference between the two systems is how they calculate benefits. ATP relates individual's pension entitlement to the best-15-year earning history throughout the working life, while NDC takes the entire lifetime labor income into account. The major implication for such a difference is that NDC creates greater incentives for postponing retirement than ATP. The reason is that workers would expect an increase in pension benefits with additional years of gaining labor income under the NDC system, but no such an increase in pension income would be expected under ATP, as the best-15-year earnings usually occur before age 50 (Laun and Wallenius, 2015). In other words, NDC participants would receive proportionally higher benefits if their lifetime earnings were greater (Palmer, 2000).

In addition to the earning history, NDC further incentivizes workers to postpone retirement by introducing the remaining life expectancy as a divisor for calculating monthly entitlements. In practice, this means the pension benefit in NDC is a steep increasing function of age because the life expectancy divisor decreases

with age. These two features imply that, compared to retiring at age 65, retiring at 66 will increase monthly pensions by about 9 percent, which increases further to roughly 20 percent if retiring at age 67 (Konberg et al., 2006). The divisor in NDC benefit accounting also implies benefit reduction for future generations if the retirement age remains unchanged. This is because the divisor will be increasingly greater across future generations, as long as the expected years of living continues to increase for younger cohorts (Hagen, 2013).

The phasing in of NDC would be gradually implemented over 16 years, according to the legislation of the 1994 pension reform. All benefits will be completely paid from the NDC system by the year 2040 (Sunden, 2006). The 1938-born cohort was the first to have their pension calculated under both systems, with one-fifth calculated based on new rules, and four-fifths based on the old rules. These proportions changed by 5 percent for each successive cohort up to those born in 1953, meaning that from the 1954 cohort onwards, benefits are accounted by a complete conversion of the accumulated pension credits from the old system into the new system (Konberg et al., 2006; Palmer, 2000; Settergren, 2001). One implication of the gradual phasing in of NDC for those born between 1938 and 1953 is that the later-born cohorts are more attached to the NDC system, and therefore need longer working lives to maintain the same level of pension entitlements. Such financial incentives might also explain the reversal of retirement age as we just described.

Given that the DI and public pension reforms were implemented at roughly the same time (in 1997 and 1999, respectively), it is difficult to isolate the employment effect of one reform from another, particularly in the post-2001 period. Therefore, we consider reforms which occurred over the last decade of the 20th century as an institutional explanation for the reversal, and examine whether there are other factors which may be more or less important than the reforms. More specifically, we are interested in whether compositional population changes in education, health, and immigrants may be relevant factors for the reversing cohort trend of mean retirement age, as shown in Figure 4.1. Our motivation for paying particular attention to these three factors follows.

## 2.4 Education and Old-Age Employment

Education and old-age employment might be positively associated for several reasons. From a labor supply perspective, educated people tend to work more because they are paid more, have more fulfilling jobs, and face fewer physical demands (Maestas and Zissimopoulos, 2010). Highly educated persons may also enter the labor market later, therefore extending working life may be compensating for the loss of pension entitlements due to years spent in school (McDaniel, 2003).

More years in employment for educated older workers may also attribute to demand-side factors. As argued by Peracchi and Welch (1994), changes in technology and increasing openness of the economy may not only increase the return to skills, but they may also have implications for the allocation of skills across and/or within industries, and consequently induce skill-related employment differentials. For example, firms are increasingly reliant on technical advancement to remain competitive in the global economy, which may create more job opportunities and higher demand for educated and skilled older workers.

Recent empirical work has consistently reported a strong and positive relationship between education and old-age work participation in Sweden. Karlsson and Olsson (2012) documented large differences in retirement age by education; the mean exit age ranged from 61.7 for those who only finished compulsory school (Frgymnasial utbildning) to 65 for post-graduates (Forskarutbildning). Johansson et al. (2014) showed significant and positive effects of education on late retirement, even after controlling for health, demographic characteristics, as well as financial incentives measured by option value. Stenberg and Westerlund (2013) argue that educational attainment at young ages, as well as later in life, matters for labor market outcomes among older workers. They showed that university education at mid-age (42-55) improved labor market survival rates over ages 61-66 by 5 percent in Sweden. Klevmarken (2010) conducted an analysis of the probability of gainful employment over age 50-69 based on a random sample of over 280,000 individuals born between 1938 and 1940 from the Swedish income register (LISA). He found that the employment effect of education was large and significantly positive. More importantly, the effect for women was more than double that of men.

Having briefly summarized theoretical and empirical literature in terms of the positive association between education and old-age employment, one might suspect that the reversal in retirement age may be attributable to cohort differences in ed-



ucation attainment, skills, as well as job opportunities, if later-born generations are better-educated and/or skilled than their earlier-born counterparts. Hence, we address this particular relationship in this paper, namely the effect of educational composition change on the cohort difference in old-age employment.

## 2.5 Health and Old-Age Employment

Health is a form of human capital (Becker, 1964; Grossman, 1972), making it an obvious candidate for explaining old-age employment. Impaired health is one of the most common reasons for departure from the labor market in Sweden, the reported cause of 41 percent of men and 47 percent of women (Albin et al., 2015). Examining the relationship between health and older workers' labor decisions is of great importance for policy. As argued by Börsch-Supan et al. (2009), if workers are physically and mentally worn out, the costs of early retirement and strain on the pay-as-you-go pension system may be large, but worth it. However, those who are healthy but inactive may be regarded as unused capacity<sup>1</sup>. Relevant policies targeting this "unused capacity" and facilitating late-life employment are needed, as scholars believe that such unused capacity does exist (Gruber and Wise, 1999, 2004).

Studies for Sweden based on register data generally find better health is associated with delayed retirement and higher work participation. For instance, Klevmarken (2010) found workers who received sickness benefits for 2-4 days a year were less likely to be in gainful employment compared to those without any sick days. Johansson et al. (2014) showed that workers in the highest health quintile were 1.6 percent less likely to exit the labor force than those in the lowest health quintile. If health variation explains old-age employment differentials, one could argue that the cohort trends in retirement age may be associated with improved average health across cohorts. Therefore, in the present study, we also examine the cross-cohort variation in health composition, as well as its relation to the overall cohort trend in old-age employment.

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<sup>1</sup>The unused capacity is defined as a suboptimal usage of human capital, leading to a level of output below the first-best equilibrium (Börsch-Supan et al., 2009).

## 2.6 Foreign Born and Old-Age Employment

The study of labor supply behavior of older workers has generally neglected the implications that foreign-born individuals may have for an ageing society. Immigrants may potentially maintain the size of labor force as well as the tax base, and could possibly improve competitiveness and productivity, ultimately boosting economic support for the ageing society (Harper, 2014). Nonetheless, whether the ageing economy may benefit from immigrant workers depends on the extent to which they integrate into the labor market and fill demand. Low levels of economic integration may become an additional burden on the society. Therefore, research on the employment of older foreign-born workers is of great importance.

Migrants to Sweden, particularly those from lesser developed countries, are generally perceived as a somewhat disadvantaged group, with poorer health, less education, and lower socio-economic position. Whether such factors further deteriorate their employment prospects during later life remains unclear, although immigrant-native wages, income, and wealth differentials have been examined extensively. Recent literature connects early life exposure to worse health conditions with an elevated risk of sickness absence over adulthood (Helgertz and Persson, 2014). Since immigrants from less-economically developed countries were likely born where the early life exposure to negative health conditions was higher than for Swedish born natives, their current health outcomes may accordingly differ. Therefore, we argue that migrants, particularly those from less developed countries, may be associated with lower employment rates at older ages.

Sweden has experienced different waves of immigration in recent decades, altering the composition of the foreign-born population based on country of origin. Hence the third question we address in this paper is whether the changing immigrant composition across cohorts matter in relation to the reversing cohort trend in old-age employment.

## 3 Data and Methods

The analysis relies on data from the Swedish Interdisciplinary Panel (SIP), which contains ample information on individual labor market outcomes, such as income and occupational attainment, as well as socio-demographic and health characteristics. SIP consists of individual level data from several different administrative

registers, including the income and taxation registers, the inpatient register and the total population register (RTB). These multiple registers are merged to create SIP-EXIT, a longitudinal database covering roughly 12 million unique individuals born between 1930 and 1980 who resided in Sweden sometime during the period 1968-2013. The database allows for studies examining individuals behavior towards the end of their labor market careers, from a life course perspective. For the present study, we extracted 13 cohorts born between 1935 and 1947 from SIP-EXIT and followed them from ages 55 to 64.

Our outcome variable is the individuals' employment status, which is defined as working if an individual received at least one basic amount (BA) as labor income during the year. Our main independent variables of interest are educational attainment, health, and country of birth. Education is categorized by primary, secondary, and university or higher educational attainment. Health is measured by the number of hospital admissions during the past year, recorded in the inpatient care register since year 1990. It is categorized by never, once, and twice or more been hospitalized. The foreign-born population is categorized into 8 regions: Africa, Asia, Balkan, Europe outside the Nordic countries, Middle East, Nordic countries outside Sweden, North America, and South America.

Our analysis is comprised of two parts. The first is a descriptive analysis which graphically presents the old-age employment differentials with respect to demographic, socio-economic, and health strata. We also show the cohort differences in education, health, and the migrants' composition, in order to verify if there are any cohort trends in these covariates. Second, we conduct a decomposition analysis to examine if the cohort reversal in old-age employment is attributable to population compositional change across cohorts. This is important for addressing the question of whether the cross-cohort variation in old-age employment is a result of the pension reforms during the 1990s, as if it was driven by reforms, we might expect little impact due to population structural change.

The decomposition analysis was conducted in three steps. We first estimated an econometric model based on the pooled sample, which includes all individuals born between 1935 and 1947 (aged 60-64), and who are observed between 1990-2011. Second, we estimate cohort-specific models to obtain estimates for each birth cohort. Finally, we conduct a Blinder-Oaxaca decomposition to quantify the contribution of population structural change and the institutional reforms to the cross-cohort variation in old-age employment.

In the first step, the data is treated as a pooled cross-section with the observation period from 1990 to 2011. The coefficient estimates were obtained using logistic regression with robust standard errors. The general specification of the econometric model may be written as:

$$y_i = \alpha + Z_i' \beta + \epsilon_i \quad (4.1)$$

where,  $y_i$  is the dichotomous outcome variable for each individual in the pooled sample, which equals 1 if employed, and zero otherwise.  $Z$  is a set of covariates including dummy indicators for each birth cohort, age, marital status, education level, health condition, and country of birth.

In the second step, we estimated the model for each birth cohort separately with the same specification as in (4.1), but excluded the cohort dummies in  $Z$ . The cohort-specific model may be simply modified as:

$$y_{i,c} = \alpha_c + X_{i,c}' \beta_c + \epsilon_{i,c} \quad (4.2)$$

where,  $c$  denotes each cohort born between 1935 and 1947, and  $X$  is a set of covariates: dummy indicators for age, marital status, education level, health condition, and country of birth.

The decomposition analysis in the third step is based on the obtained estimates for  $\alpha, \beta, \alpha_c, \beta_c$  in (4.1) and (4.2), together with the observed population characteristics  $X_{i,c}$ . As stressed earlier, our central interest is to examine the effect of cross-cohort compositional differences in education, health, and native-foreign born population on the reversing cohort trend of old-age employment. Hence we set the 1935 birth cohort as the reference category and make pair-wise comparisons with each later-born cohort. The average difference between the reference cohort and each later born in the outcome variable  $y_i$  can be expressed as:

$$dY = E(Y_c) - E(Y_{1935}) = \alpha_c - \alpha_{1935} + E(X_c)' \beta_c - E(X_{1935})' \beta_{1935} \quad (4.3)$$

where,  $c$  denotes each cohort born between year 1936 and 1947.

Following Jann (2008), we apply a two-fold decomposition by including a “nondiscriminatory” coefficient vector to determine the contribution of  $X$ . Thus letting  $\alpha^*$  and  $\beta^*$  be such vectors for the constants and coefficients, (4.3) can be rewritten as:

$$\begin{aligned} dY = & (\alpha_c - \alpha^*) - (\alpha_{1935} - \alpha^*) + [E(X_c) - E(X_{1935})]' \beta^* \\ & + [E(X_c)' (\beta_c - \beta^*) - E(X_{1935})' (\beta_{1935} - \beta^*)] \end{aligned} \quad (4.4)$$

The term  $[E(X_c) - E(X_{1935})]' \beta^*$  in (4.4) is the differences in the outcome variable attributable to the changing mean value in covariates (differences in the employment rate that is explained by differences in the composition of covariates). The sum of the remaining terms on the right hand side of (4.4) is the difference in outcome due to coefficient change (the unexplained differences in the employment rate). In the present context, we interpret the explained part as the contribution of compositional change in population to the overall cohort differences in old-age employment. The unexplained part is therefore the effects of non-compositional change. Hence, (4.4) can be simplified as:

$$dY = dX + dB \quad (4.5)$$

where,  $dX$  refers to the impact of compositional change and  $dB$  refers to the influence of institutional change, mainly the pension reforms.

One might argue that  $dB$  is essentially the consequence of pension reforms, as the cross-cohort variation in old-age employment corresponds to the disproportional effect of policy change on the expected pension entitlements. However,  $dB$  can also arise from preference changes which are independent of the reforms. For instance, later-born cohorts may work more simply because of different work-leisure preferences compared with earlier-born cohorts. We realize this limitation of our decomposition analysis, and argue that our estimates on the  $dB$  merely reflect the residual effect of old-age employment variation, while the relative importance due to pension reforms, behavioral modification, changes in working culture and norms, as well as demand for old-age labor remain unknown.

One final note concerning the decomposition analysis regards the unknown parameters  $\alpha^*$  and  $\beta^*$ . Some argue that the nondiscriminatory parameters should be determined by imposing weights, either by averaging the coefficient estimates obtained from each pair-wise regression or by groups sizes (Cotton, 1988; Reimers, 1983). However, since our decomposition relies on pair-wise comparison, imposing weights would induce variation in  $\alpha^*$  and  $\beta^*$  across cohorts. This, as can be seen from (4.4), might alter the contribution of  $dX$ . Thus, we choose to follow the approach by Neumark (1988) and Oaxaca and Ransom (1994), using the coefficients from a pooled regression. Their methods rely on the pooled regression over each of the paired groups, which can still result in variations in the nondiscriminatory parameters across cohorts. Hence, in order to hold  $\alpha^*$  and  $\beta^*$  not only constant, but representative for all cohorts, we determine the parameter vectors by using the estimates obtained from (4.1), which is the pooled regression for the

whole sample born 1935-47. Therefore,  $\alpha^* = \alpha$  and  $\beta^* = \beta$ .

## 4 General Old-Age Employment Pattern

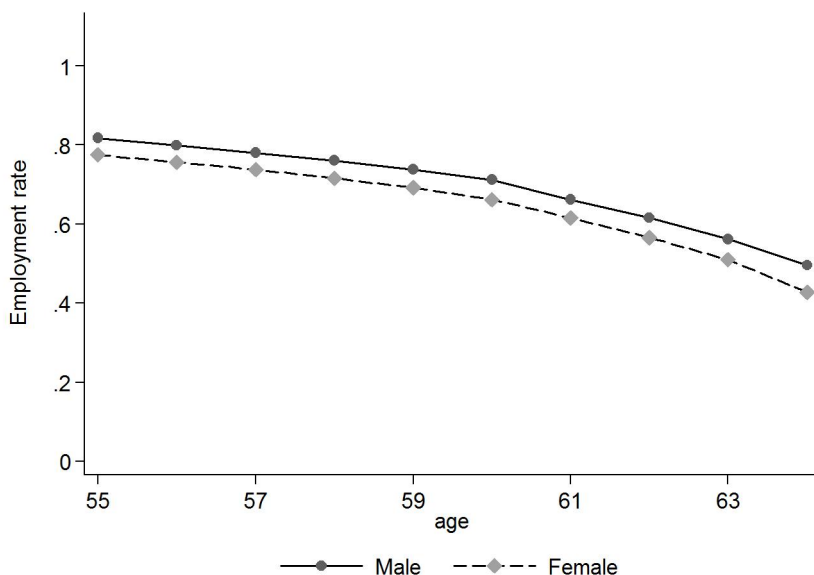
Figure 4.2 depicts the general pattern of employment over the later life-cycle, exhibiting a downward trend. The employment rate dropped from around 80% at age 55 down to below 50% at age 64. The rate of decline is essentially identical between men and women. The downward slope is by no means a surprising phenomenon. It exemplifies the age-earning profile that typically peaks around age 50, and gradually declines thereafter; a pattern which has been uncovered in 17 out of 19 OECD countries (Skirbekk, 2003). As predicted by the inter-temporal substitution hypothesis, workers are assumed to anticipate a wage drop over the course of their later careers, and in response to such evolutionary wage declines, rational agents would demand more leisure (and thus supply less labor) when wages are low (Macurdy, 1981).

However, an important feature from Figure 4.2 is that the relationship between employment rate and age is non-linear, as the downward slope gets steeper after age 60. Such a drop might be too steep to be explained by decreasing wages at older ages, casting doubt on the explanatory power of the inter-temporal substitution hypothesis for the employment pattern over this particular segment of the life cycle. In fact, Qi (2015) showed that the employment response to wage change at ages 60-64 tends to be dominated by income effects rather than substitution effects (neither intra-, nor inter-temporal), and therefore, lends support to the backward-bending labor supply curve. Nonetheless, the macro data used in Qi (2015) does not allow incorporating financial incentives into the empirical estimation, which is an important factor, since benefits from the public earnings-related pensions are payable from age 60 in ATP and 61 in NDC in Sweden<sup>2</sup>. Thus the estimates possibly overstate the true income effect of wage changes on employment. One might expect the wage effect on labor supply to diminish once pension income is controlled for.

Moreover, the age-employment profile in the present study should differ by cohort if it reflects the impact of public pension reform. This is because our sample contains cohorts both completely covered by the ATP system (those born before 1938)

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<sup>2</sup>ATP is the public earnings-related pension prior to the 1994 pension reform and NDC is the post-reform scheme.



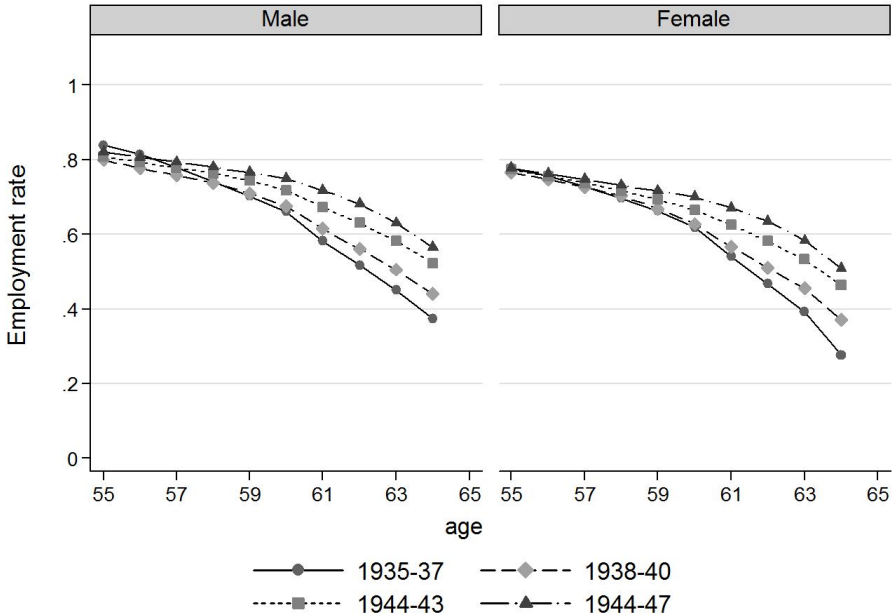
**Figure 4.2:** Age pattern of employment by gender, sample cohort 1935-47 for years 1990-2011

and by the hybrid system (the transitional cohorts who were born in 1938 or later). Recalling from the previous discussion, those born later require longer working lives in order to maintain the same level of pension entitlements, thus we expect the employment decline after age 60 to be less steep for the younger generation.

Indeed, as shown in Figure 3, there are large differences across cohorts in the age pattern of employment. The overall pattern exhibits a downward trend, similar to Figure 4.2. However, comparing the older cohorts with the younger ones, the age-profile of employment shifts towards older age. The cohort employment differential accentuates with increased age, and is particularly profound from age 60 onwards. Hence, the apparent interactive effect between cohort and age might be supporting evidence for the employment effects of the old-age pension reform in 1994. This reform effect also seems equally distributed between genders, as the shifting pattern towards older age is similar for both sexes.

Evidence in Figure 4.3 is also in line with the institutional explanation for the re-

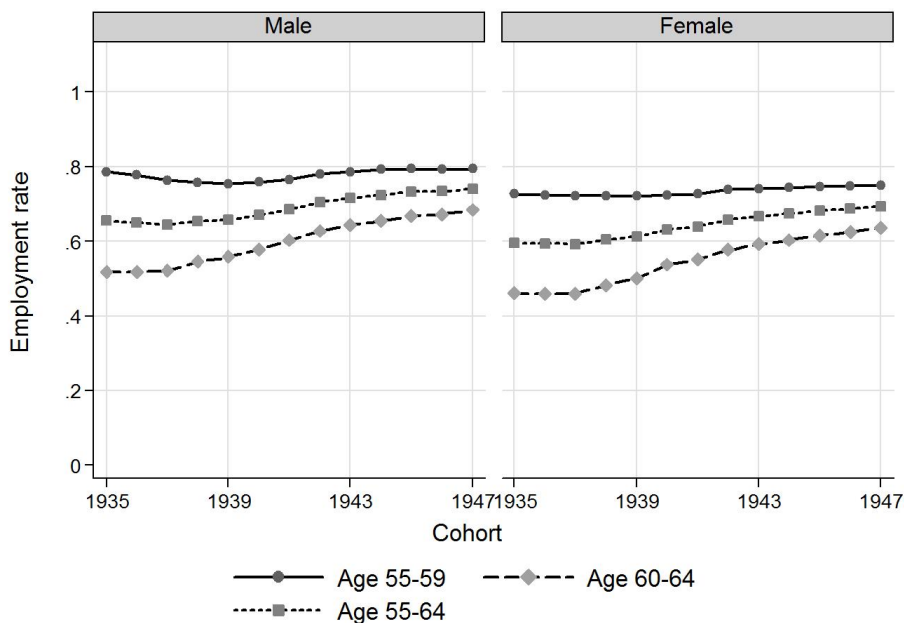
versing cohort trend in retirement age by Karlsson and Olsson (2012). To illustrate the cohort differences in old-age employment rates, we plot the cohort trend in employment rates in Figure 4.4. As we just discussed, the age pattern, as well as the cohort differences, are quite distinguishable between ages 55-59 and 60-64, thus the cohort trend is further disaggregated into two age groups in Figure 4.4.



**Figure 4.3:** Age pattern of employment by cohort and gender, sample cohort 1935-47 for years 1990-2011

The overall cohort-specific employment rate for the entire sample (aged 55-64) is trending upward for both sexes, as shown by the middle connected line in both panels in Figure 4.4. However, by disaggregating this trend into two sub-groups, it becomes evident that the upward trend is mainly driven by the older age group, those aged 60-64. There is essentially no trend among those aged 55-59, but steep growth for those aged 60-64. Together with the pattern in Figure 4.3, which shows the shift of the age profile of employment is more profound between ages 60-64 than 55-60, this graphical evidence implies that the reversing cohort trend in old age employment is attributable to pension reforms, as it appears to only affect the





**Figure 4.4:** Cohort trends in employment by age and gender, sample cohort 1935-47 for years 1990-2011

older age group.

Since our main interest in this paper is the reversing cohort trend in old-age employment, and the major change occurs within the 60-64 age group, the remainder of the paper will focus its analysis on the cross-cohort variation in aged 60-64 employment.

## 5 Cohort Trends in Population Composition and Old-age Employment

The key question of this paper is whether the reversing cohort trend is associated with population compositional change, such as education, health, and/or immi-

grants. Therefore, in this section, we describe some feature of each of the covariates. We primarily focus on the cohort differences in the composition of the population and the old age employment differentials with respect to demographic, socio-economic, and health strata.

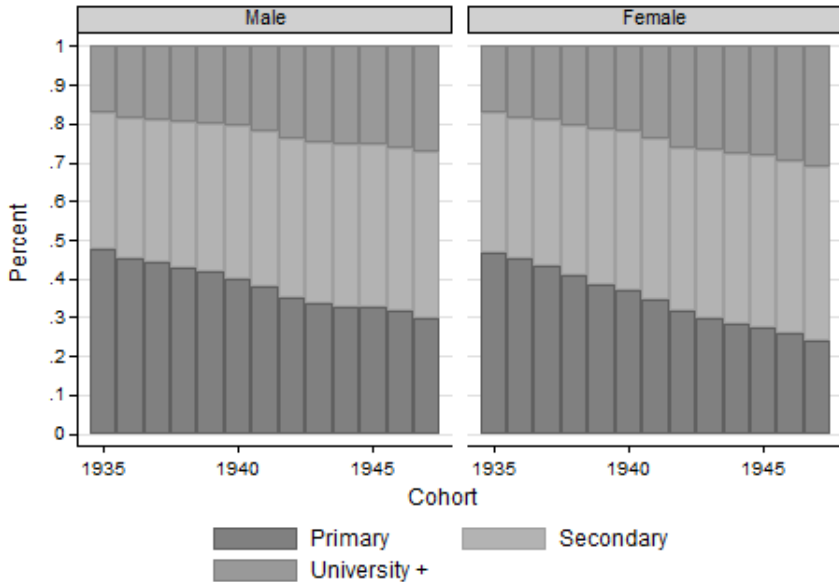
## 5.1 Education and Later-Life Employment

Figure 4.5 illustrates the cross-cohort differences in educational composition. The shifting educational composition across cohorts is clearly evident, a compositional change that is more profound among women than men. Among those born between 1935 and 1947, the share with primary education declined from roughly 50 to 30 percent for men and from 50 to 23 percent for women, while those with university education grew to 28 percent for men and 30 percent for women.

Recalling our earlier discussion on the theoretical prediction that educated workers are more likely to be in employment at older ages (Maestas and Zissimopoulos, 2010; McDaniel, 2003; Peracchi and Welch, 1994), if this holds, the growing share of highly educated across cohorts may translate into an overall increase in employment. However, whether the changing educational composition matters for the cohort trend in old-age employment would also depend on changes in the employment differentials across educational groups. This is illustrated by Figure 4.6, which shows the cohort trends of employment rate by education and sex among those aged 60-64.

The first insight from Figure 4.6 is that the growth of employment rate across cohorts occurred at all levels of education. The implication of such a parallel trend among educational groups is that the employment differentials do not vary across cohorts. This evidence is in stark contrast to the reversing early retirement in Germany, where pension policy reform led to a growing gap between low and medium educated groups for the timing of employment exit (Buchholz et al., 2013).

Despite employment differentials with respect to education not increasing, it did persist to the same magnitude across cohorts. The differences in cohort trends across education levels suggest that education and old-age employment are positively associated, lending support to the above-mentioned theoretical assumptions. This positive relationship is in line with previous empirical findings based on a similar data source (Johansson et al., 2014; Klevmarken, 2010; Stenberg and Westerlund, 2013).



**Figure 4.5:** Educational composition over cohort, 1935-47

However, the overall educational differences in cohort trends are greater among women than men. The difference between those with primary and secondary education is much smaller for men than women, with the gender difference noticeably smaller amongst the university+ educated, compared to those with primary and secondary education.

Given the consistent high employment rate among the highly educated and the increasing share of the population with tertiary education across cohorts, one might expect a positive relationship between the changes in education composition and old-age employment across cohorts. This relationship will be explicitly examined in the decomposition analysis.



Figure 4.6: Cohort trend in age 60-64 employment by education and sex

## 5.2 Health and Later-life employment

As previously mentioned, impaired health is one of the most common reasons for departure from the labor market (Albin et al., 2015). One might expect poor health to be associated with lower probability of working. This section describes whether such association might exist in Sweden based on our data. Moreover, cross-cohort variation in health is also presented due to its relevance for addressing our key question; whether the health composition of the older-aged labor force varied by cohort, and whether such change led to old-age employment growth.

Health is measured by number of hospital admissions during the past observation year. We further categorize the variable into: 1) no admissions 2) one admission and 3) two or more admissions. Figure 4.7 shows the cohort trend in health composition. Unlike educational composition, the cohort differences in health composition are much less profound, although a small improvement in health over

time can be seen. The share with no hospital admissions was 88% for the 1935 cohort, and increased to 89% for men and 90% for women born in 1947. Conversely, both the share of 1 admission and 2+ admissions were lowered by one percentage point.

Figure 4.8 shows the cohort trends of employment rate by health and sex among those aged 60-64. The overall relation between health and old-age employment is positive. The employment rate was the highest for those never hospitalized, whereas those who were admitted twice or more was the lowest. This implies that better health (or less hospital admissions) was associated with higher employment, and conversely impaired health reduced the probability of working. Such evidence is in line with previous empirical findings using the Swedish register data (Johansson et al., 2014; Klevmarken, 2010). Moreover, the health-employment relationship appears linear for both genders, as the difference between the 0 and 1 admission equals the difference between 1 and 2+ admissions, more or less. Such differentials persist over all cohorts, and are common for both men and women.

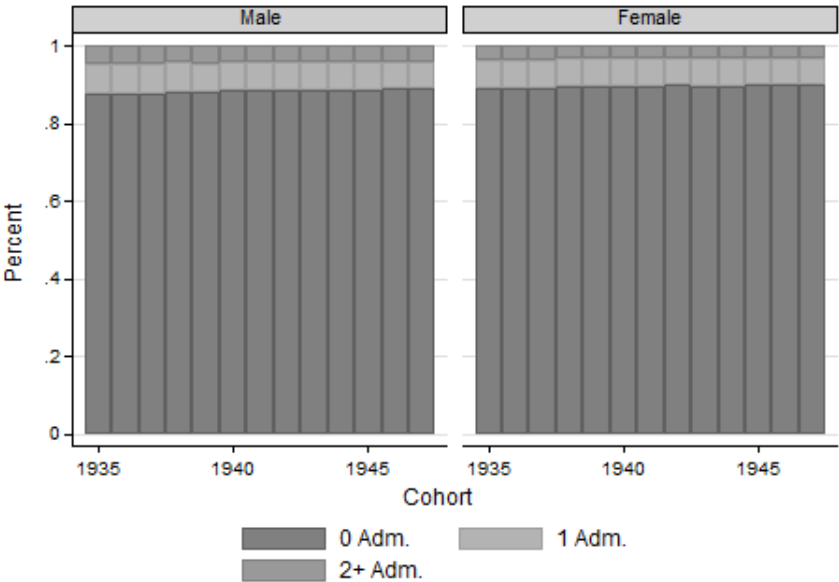
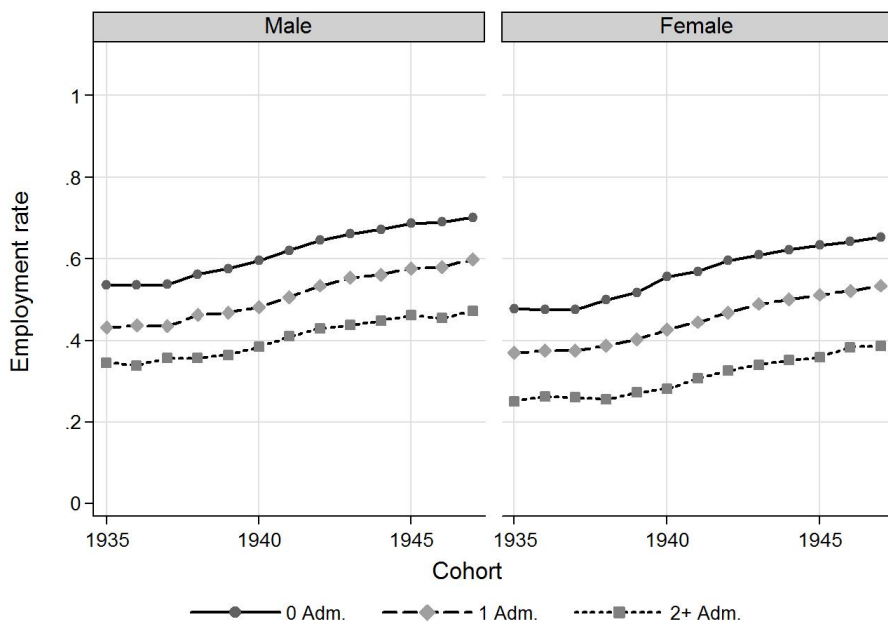


Figure 4.7: Health composition over cohort, 1935-47



**Figure 4.8:** Cohort trend in age 60-64 employment by health and sex

As stressed earlier, those who are healthy, but inactive in the labor market may be regarded as “unused capacity” (Börsch-Supan et al., 2009). Such “unused capacity” seems to exist in Sweden, more so among the older cohorts, and among women. The employment rate for healthy workers grew from 53% to 70% for men and from 48% to 65% for women between the 1935 and 1947 cohorts. However, Figure 4.7 shows that around 90% of the population aged 60-64 has never been hospitalized, a proportion which is constant for men and women over the cohorts. This has two implications. First, the difference in the employment rate among healthy workers between the oldest and youngest cohorts implies that unused capacity was reduced by 17 percentage points in employment for both sexes. Second, despite this unused capacity reducing substantially across cohorts, it still remained at 20% for men and 25% for women, respectively. In other words, 20% of men and 25% of women aged 60-64, who were born in 1947, were healthy but inactive in the labor market. This lends support for the argument that such unused capacity does exist (Gruber and

Wise, 1999, 2004).

Given the little variation in health composition across cohorts (as shown in Figure 4.7), the upturn trend in employment is likely not attributable to health development across cohorts, even though a general health-employment relationship exists. This point will be more explicitly examined in our decomposition analysis.

### 5.3 Foreign Born and Later-Life Employment

The labor market exit behavior among foreign-born older workers has been studied to a minimal extent in the retirement literature. This is partially due to the fact that the share of foreign-born population is much smaller than for natives. Random samples of the population typically do not have a sufficient number of observations of foreign workers. Quite often, native-immigrant differences in labor market outcomes are captured by including a dummy indicator, but detailed analysis by country of birth is rare. The SIP-EXIT covers the entire population in Sweden, thus we are able to examine the native-immigrant employment differentials in a detailed manner.

Figure 4.9 shows the size of each migrant group aged 60-64 as a share of the total population. The majority of the foreign-born population within each cohort came from the Nordic region (Denmark, Finland, Norway, and Iceland). European immigrants outside the Nordic region were the second largest group. The third largest group were the Balkans, and the fourth largest group came from the Middle East, including Turkey, Iran, Iraq, and Lebanon. The remaining and smallest portion of the foreign-born population originate from Africa, Asia, North America and South America.

Although the foreign composition does vary slightly across cohorts, the population is still dominated by the Swedish native-born, who comprised nearly 90% across all the cohorts. Hence, the overall compositional change in native-immigrant population appears to be negligible.

Figure 4.10 shows the cohort trends of employment rate by the foreign-born categories and sex. It is evident that the variation in old-age employment is large across the native- and foreign-born populations. Not only do employment levels differ, but also across the cohort trend. The groups who most closely resemble natives are: Nordic, European, North American men and women, and South American

men. The most striking feature in Figure 4.10 is that the employment rates for those from the Balkan and Middle East countries were, on average, 35% lower for men and 43-45% lower for women, compared to natives.

Since the cohort differences in the ethnic composition of the population are small, mainly dominated by the native-born. Additionally, the cohort trends in employment across various immigrant groups are much more complex than education and health strata; it is, therefore, hard to say a priori whether these cross-cohort variations matter for the old-age employment reversal. We thus address this question explicitly in our decomposition analysis.

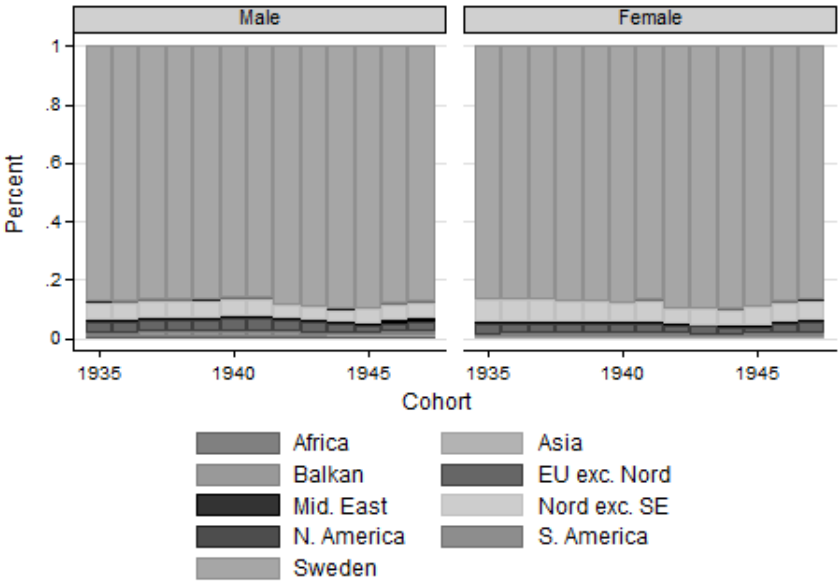


Figure 4.9: Native and foreign-born population composition over cohort, 1935-47



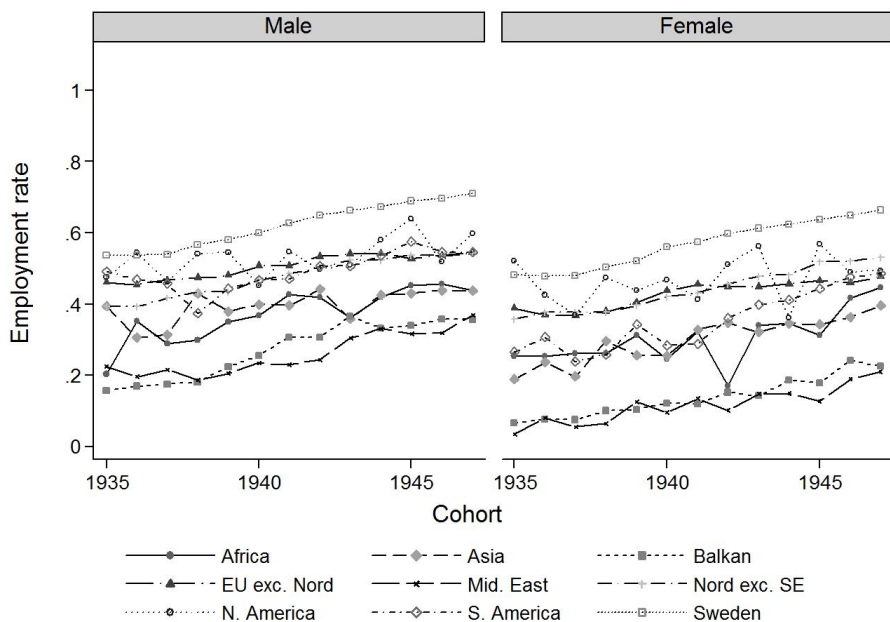


Figure 4.10: Cohort trend in age 60-64 employment by country of origin and sex

## 5.4 Descriptive Summary

Table 4.1 highlights what has been discussed so far regarding the cohort change in old-age employment by socio-economic, demographic and health strata. Between the oldest and youngest birth cohorts, the overall employment change for women was 2 percentage points higher than for men.

**Table 4.1:** Summary of cohort differences in age 60-64 employment rates by sex

Variable	Employment Rate					
	Male			Female		
	1935	1947	Diff.	1935	1947	Diff.
Overall	0.52	0.68	0.16	0.46	0.64	0.18
Education						
Primary	0.48	0.64	0.16	0.39	0.51	0.12
Secondary	0.51	0.67	0.16	0.47	0.62	0.15
University+	0.64	0.75	0.11	0.64	0.76	0.12
Health						
0 admission	0.53	0.7	0.17	0.48	0.65	0.17
1 admission	0.43	0.6	0.17	0.37	0.53	0.16
2+ admission	0.35	0.47	0.12	0.25	0.39	0.14
Birth Country						
Africa	0.2	0.44	0.24	0.25	0.45	0.2
Asia	0.39	0.44	0.05	0.19	0.4	0.21
Balkan	0.16	0.36	0.2	0.07	0.23	0.16
Europe outside Nordic	0.46	0.54	0.08	0.39	0.48	0.09
Middle East	0.22	0.37	0.15	0.03	0.21	0.18
Nordic outside Sweden	0.39	0.54	0.15	0.36	0.53	0.17
North America	0.48	0.6	0.12	0.52	0.5	-0.02
South America	0.49	0.55	0.06	0.27	0.48	0.21
Sweden	0.54	0.71	0.17	0.48	0.66	0.18

Across three levels of educational attainment, the cohort trend among men was steepest for those who only completed primary and secondary education. However, for women, the sharpest growth occurred among those with secondary education. Health does seem to matter for the employment change across cohorts, as those who had been hospitalized no times, or once, during the past year, had a higher increase than those with a worse health condition. The cohort employment curve varies substantially across foreign-born and native populations. Despite that employment differentials based on country of origin do exist among the later born, some minority groups are catching up in old-age employment (African and Balkan

men, and African, Asian, and South American women).

## 6 Decomposition Analysis

The decomposition analysis is based on econometric models (4.1) and (4.2), where the probability of working is written as a function of the covariates in  $Z$  for the whole sample and  $X$  for the cohort-specific estimation. We conduct the decomposition for both genders separately. The regression results are presented in Table 4.2 for men and Table 4.3 for women. We begin our discussion with the first columns of Table 4.2 and Table 4.3, which corresponds to the estimation based on the pooled sample including all individuals born from 1935-47 (aged 60-64), and observed over the period 1990-2011.

All coefficients in the pooled model are with expected signs and statistically significant at conventional levels. Education was positively associated with the probability of working for both men and women in all age groups. However, it is important to note that the educational differences in employment were much larger among women than men. This coincides with the cohort trend shown in Figure 4.6, in which the employment gap between the highly educated and lower educated was consistently wider for women than men.

Health does seem to matter for old-age employment for both sexes. However, hospital admission during the past year seems to have affected women slightly more than men. For example, among those being admitted to hospital more than twice, the probability of working was reduced 57% for men, and 66% for women, compared to those who were never hospitalized.

Another important observation in our regression results is the large employment differences across the native and foreign born populations. The probability of working for all immigrants was substantially lower than for native-born, with the estimated odds ratios ranging from over 0.18 to 0.58 for men and 0.11 to 0.62 for women. Considering the gender dimension, native-immigrant differentials were more profound for women than men among those from Balkan, European other than Nordic, Middle East, North and South American countries, while equally large for men and women born in Africa and Asia. Most interestingly, native-immigrant differentials were smaller for women than men among the immigrants from other Nordic countries. As shown in Figure 4.10, the most striking differ-

ences in employment rates were between the native-born population and immigrants from the Balkans and the Middle East. These differences corresponded to about 80% for men and nearly 90% for women based on our regression results.

The second through the last column of Table 4.2 and Table 4.3 present coefficient estimates for each cohort-specific model. We uncovered cross-cohort variation in some estimates. The most important feature is the increasing odds ratios within each age category across birth cohorts. This implies the age-employment profile shifted towards older ages, the pattern we have already shown in Figure 4.3.

Regarding education, coefficients for men show a pattern of increasing odds ratios, suggesting that educational differences in employment diminish over cohorts. However, this pattern did not occur among female workers. On the other hand, impaired health appears to have increasingly affected the odds of employment negatively for men, as the odds ratios for 2+ admissions decreased across the cohorts. The same coefficients for women, however, remained fairly constant across cohorts. Finally, the native-immigrant differentials widened among men from Asia, Europe, and South America, while diminished among those from Balkan countries. For female foreign-born workers, most groups have increasingly closed the native-immigrant gap (or holding constant), except the European and North American immigrants.

We used the estimates from Tables 4.2 and 4.3 to implement the Blinder-Oaxaca decomposition analysis. The results for men and women are graphically presented in the following figures (see Table 4.4 and Table 4.5 for detailed results).

Table 4.2: Logit estimates of probability of working, pooled and cohort samples for men

VARIABLES	Pooled	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
Age														
60	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
61	0.782***	0.736***	0.697***	0.679***	0.734***	0.742***	0.800***	0.788***	0.792***	0.809***	0.833***	0.853***	0.843***	0.841***
62	0.631***	0.554***	0.504***	0.541***	0.562***	0.595***	0.636***	0.636***	0.646***	0.683***	0.709***	0.725***	0.709***	0.669***
63	0.498***	0.393***	0.393***	0.416***	0.447***	0.475***	0.499***	0.516***	0.520***	0.562***	0.578***	0.581***	0.541***	0.520***
64	0.377***	0.280***	0.283***	0.307***	0.341***	0.362***	0.386***	0.396***	0.405***	0.439***	0.447***	0.421***	0.401***	0.398***
Marital Status														
Unmarried	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Married	1.772***	1.768***	1.705***	1.807***	1.709***	1.743***	1.733***	1.760***	1.731***	1.760***	1.766***	1.812***	1.815***	1.880***
Education														
Primary	0.604***	0.539***	0.574***	0.547***	0.609***	0.576***	0.546***	0.600***	0.615***	0.612***	0.653***	0.646***	0.648***	0.633***
Secondary	0.663***	0.607***	0.671***	0.640***	0.669***	0.642***	0.619***	0.630***	0.661***	0.659***	0.704***	0.684***	0.679***	0.692***
University+	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Health														
o Admission	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
i Admission	0.657***	0.676***	0.687***	0.676***	0.678***	0.667***	0.648***	0.644***	0.645***	0.655***	0.635***	0.640***	0.643***	0.659***
2+ Admission	0.436***	0.476***	0.463***	0.504***	0.455***	0.445***	0.445***	0.442***	0.438***	0.418***	0.421***	0.418***	0.395***	0.411***
Country of Origin														
Sweden	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Africa	0.321***	0.190***	0.430***	0.314***	0.307***	0.351***	0.350***	0.410***	0.375***	0.253***	0.306***	0.336***	0.324***	0.286***
Asia	0.317***	0.446***	0.314***	0.323***	0.472***	0.365***	0.376***	0.324***	0.368***	0.240***	0.315***	0.291***	0.289***	0.271***
Balkan	0.203***	0.136***	0.153***	0.160***	0.152***	0.193***	0.211***	0.251***	0.221***	0.275***	0.221***	0.205***	0.212***	0.202***
EU excl. Nord.	0.570***	0.662***	0.651***	0.690***	0.648***	0.611***	0.633***	0.577***	0.586***	0.558***	0.530***	0.468***	0.461***	0.442***
Middle East	0.176***	0.210***	0.176***	0.194***	0.152***	0.159***	0.171***	0.145***	0.147***	0.190***	0.202***	0.173***	0.166***	0.195***
Nord. excl. SWE	0.579***	0.576***	0.582***	0.645***	0.616***	0.589***	0.624***	0.595***	0.582***	0.601***	0.565***	0.566***	0.521***	0.513***
North America	0.560***	0.647***	0.909	0.654***	0.774*	0.658***	0.475***	0.606***	0.465***	0.455***	0.591***	0.678***	0.381***	0.494***
South America	0.545***	0.746***	0.698***	0.689***	0.433***	0.540***	0.566***	0.509***	0.535***	0.518***	0.544***	0.585***	0.515***	0.498***
Observations	3,386,543	199,661	205,851	212,391	221,648	231,480	230,480	240,997	273,321	295,839	316,620	320,591	321,793	315,871
Pseudo R-squared	0.0701	0.0711	0.0672	0.0656	0.0602	0.0602	0.0595	0.0581	0.0562	0.0531	0.0521	0.0579	0.0633	0.0673

Significance: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 4.3: Logit estimates of probability of working, pooled and cohort samples for women

VARIABLES	Pooled	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
								Age						
60	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
61	0.802***	0.758***	0.708***	0.671***	0.745***	0.722***	0.817***	0.820***	0.831***	0.841***	0.847***	0.876***	0.883***	0.874***
62	0.643	0.555***	0.496***	0.516***	0.549***	0.591***	0.651***	0.665***	0.684***	0.698***	0.724***	0.752***	0.739***	0.717***
63	0.505***	0.375***	0.367***	0.383***	0.430***	0.477***	0.514***	0.540***	0.544***	0.575***	0.584***	0.600***	0.573***	0.579***
64	0.352	0.204***	0.211***	0.231***	0.285***	0.313***	0.391***	0.394***	0.410***	0.435***	0.436***	0.429***	0.412***	0.416***
								Marital Status						
Unmarried	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Married	1.074***	0.982*	0.973***	0.977**	1.023**	1.023**	1.057***	1.106***	1.097***	1.112***	1.107***	1.113***	1.129***	1.154***
								Education						
Primary	0.347***	0.347***	0.361***	0.367***	0.381***	0.380***	0.326***	0.319***	0.332***	0.346***	0.345***	0.337***	0.334***	0.345***
Secondary	0.495***	0.486***	0.509***	0.509***	0.509***	0.514***	0.481***	0.469***	0.469***	0.487***	0.490***	0.497***	0.494***	0.514***
University+	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
								Health						
o Admission	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
1 Admission	0.618***	0.640***	0.646***	0.652***	0.624***	0.617***	0.590***	0.606***	0.605***	0.611***	0.612***	0.613***	0.612***	0.616***
2+ Admission	0.342***	0.362***	0.386***	0.373***	0.345***	0.345***	0.315***	0.336***	0.328***	0.338***	0.334***	0.328***	0.350***	0.335***
								Country of Origin						
Sweden	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Africa	0.327***	0.372***	0.327***	0.331***	0.310***	0.340***	0.204***	0.327***	0.135***	0.336***	0.330***	0.261***	0.410***	0.432***
Asia	0.313***	0.233***	0.328***	0.237***	0.397***	0.304***	0.246***	0.354***	0.368***	0.303***	0.318***	0.300***	0.304***	0.343***
Balkan	0.130***	0.074***	0.089***	0.087***	0.113***	0.111***	0.118***	0.108***	0.135***	0.112***	0.153***	0.136***	0.193***	0.165***
EU excl. Nord.	0.494***	0.617***	0.565***	0.563***	0.534***	0.558***	0.536***	0.542***	0.491***	0.443***	0.441***	0.439***	0.403***	0.418***
Middle East	0.105***	0.041***	0.105***	0.068***	0.075***	0.142***	0.091***	0.123***	0.080***	0.112***	0.107***	0.083***	0.126***	0.134***
Nord. excl. SWE	0.621***	0.612***	0.674***	0.675***	0.615***	0.622***	0.591***	0.597***	0.594***	0.618***	0.590***	0.650***	0.621***	0.614***
North America	0.476***	0.887	0.666***	0.525***	0.706**	0.527***	0.488***	0.352***	0.504***	0.660***	0.250***	0.540***	0.383***	0.347***
South America	0.402***	0.370***	0.456***	0.314***	0.327***	0.469***	0.278***	0.268***	0.357***	0.400***	0.391***	0.454***	0.471***	0.491***
Observations	3,371,820	203,022	211,939	214,647	224,308	231,781	227,470	238,869	266,754	292,153	309,752	315,186	319,505	316,434
Pseudo R-squared	0.0812	0.0911	0.0849	0.0793	0.0721	0.0663	0.0723	0.0715	0.0693	0.0644	0.0642	0.0680	0.0695	0.0712

Significance: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 4.4: Decomposition results, men

	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
Y	0.518***	0.521***	0.545***	0.559***	0.578***	0.603***	0.628***	0.644***	0.655***	0.669***	0.673***	0.685***
dY	-0.000	0.003	0.027***	0.041***	0.060***	0.085***	0.110***	0.126***	0.137***	0.151***	0.155***	0.167***
dX	0.002	0.001	0.001	0.000	-0.001*	0.000	0.006***	0.008***	0.008***	0.007***	0.003***	0.003***
dB	-0.002	0.002	0.026***	0.041***	0.061***	0.085***	0.104***	0.118***	0.129***	0.144***	0.152***	0.164***
	Overall											
Age	0.000	0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
Marital	0.000	-0.001***	-0.002***	0.001	-0.003***	-0.008	-0.004***	-0.005***	-0.006***	-0.008***	-0.010***	-0.010***
Education	0.002***	0.003***	0.004***	-0.001	0.004***	0.011	0.009***	0.010***	0.011***	0.011***	0.012***	0.014***
Hospital	0.000	0.000**	0.001***	-0.000	0.001***	0.002	0.001***	0.001***	0.001***	0.002***	0.002***	0.002***
Birth Country	-0.000	-0.001***	-0.001***	0.000	-0.003***	-0.005	0.000	0.002***	0.003***	0.002***	-0.000*	-0.003***
	dB											
Age	-0.000	-0.000*	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.001***	-0.001***	-0.000***	-0.000***	-0.000***
Marital	-0.002*	0.001	-0.001*	-0.001	-0.001	-0.000	-0.001	-0.000	0.000	0.001	0.001	0.002***
Education	0.003***	0.001*	0.004***	0.003***	0.001*	0.003***	0.004***	0.004***	0.005***	0.004***	0.004***	0.004***
Hospital	0.001	-0.003	0.003	0.005*	0.007**	0.008**	0.008**	0.010***	0.012***	0.012***	0.015***	0.011***
Birth Country	-0.019	-0.006	0.001	-0.003	-0.001	-0.003	0.005	0.015*	0.001	0.003	0.023***	0.019**
constant	0.015	0.009	0.020*	0.036***	0.055***	0.077***	0.089***	0.090***	0.111***	0.125***	0.110**	0.128***
N	405,512	412,052	421,309	431,141	430,141	440,658	472,982	495,500	516,281	520,252	521,454	515,532
N cohort 1936-47	205,851	212,391	221,648	231,480	230,480	240,997	273,321	295,839	316,620	320,591	321,793	315,871
N cohort 1935	199,661	199,661	199,661	199,661	199,661	199,661	199,661	199,661	199,661	199,661	199,661	199,661

Significance: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

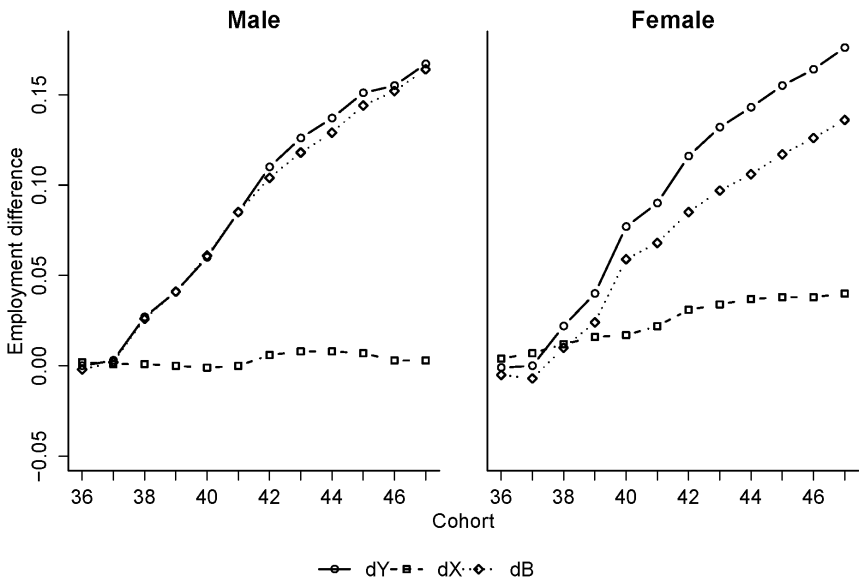
Table 4.5: Decomposition results, women

	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
Y	0.460***	0.461***	0.483***	0.501***	0.537***	0.551***	0.577***	0.593***	0.604***	0.616***	0.625***	0.636***
dY	-0.001	-0.000	0.022***	0.040***	0.077***	0.090***	0.116***	0.132***	0.143***	0.155***	0.164***	0.176***
dX	0.004***	0.007***	0.012***	0.016***	0.017***	0.022***	0.031***	0.034***	0.037***	0.038***	0.038***	0.040***
dB	-0.005***	-0.007***	0.010***	0.024***	0.059***	0.068***	0.085***	0.097***	0.106***	0.117***	0.126***	0.136***
	Overall											
Age	0.000	0.000	0.000	-0.000	-0.000	0.000	-0.000	0.000	-0.000	-0.000	-0.000	-0.000
Marital	-0.000**	-0.000***	-0.000***	-0.000***	-0.000***	-0.001***	-0.000***	-0.000***	-0.001***	-0.001***	-0.001***	-0.001***
Education	0.003***	0.006***	0.010***	0.014***	0.016***	0.021***	0.026***	0.029***	0.032***	0.034***	0.037***	0.041***
Hospital	0.001**	0.001***	0.001***	0.001***	0.001***	0.001***	0.002***	0.001***	0.001***	0.002***	0.002***	0.002***
Birth Country	0.000	0.000	0.001***	0.001***	0.000*	0.000*	0.004***	0.004***	0.005***	0.003***	0.000	-0.003***
	dX											
Age	0.000	-0.000	-0.000*	-0.000**	-0.000***	-0.000***	-0.000***	-0.001***	-0.001***	-0.000***	-0.000***	-0.000***
Marital	-0.000	-0.000	0.001***	0.001***	0.002***	0.004***	0.003***	0.004***	0.004***	0.004***	0.004***	0.004***
Education	0.002	0.002*	0.002***	0.002**	-0.001	-0.001*	-0.001	-0.000	-0.000	0.001	0.001	0.001*
Hospital	-0.008	-0.005	0.004	0.005	0.013***	0.008**	0.009***	0.007*	0.008**	0.009**	0.005	0.007**
Birth Country	-0.049*	0.006	-0.017	-0.030*	0.008	-0.008	0.004	-0.025*	-0.007	-0.015	-0.033***	-0.034***
constant	0.050	-0.011	0.021*	0.047***	0.037***	0.067***	0.070***	0.113***	0.103***	0.119***	0.150***	0.158***
N	414,961	417,669	427,330	434,803	430,492	441,891	469,776	495,175	512,774	518,208	522,527	519,456
N cohort 1936-47	211,939	214,647	224,308	231,781	227,470	238,869	266,754	292,153	309,752	315,186	319,505	316,434
N cohort 1935	203,022	203,022	203,022	203,022	203,022	203,022	203,022	203,022	203,022	203,022	203,022	203,022

Significance: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1



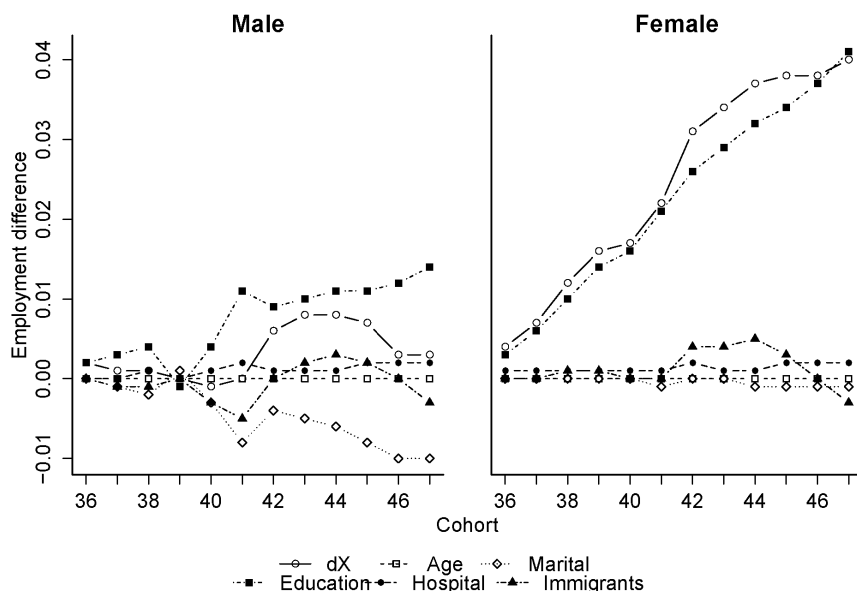
The circled line in Figure 4.11 illustrates the total difference in employment rate between cohort 1935 and each of the successive later-born cohorts. The growing differences indicated by the circled line across cohorts reflect the cohort trend in old-age employment, that we showed and discussed in Figure 4.4 for ages 60-64. The circled line is overlapped with the diamond line for men, suggesting that the cohort trend of old-age employment was entirely driven by coefficient change,  $\delta B$  in equation (4.5). This implies that the residual effect dominated the compositional change on the old-age employment. For women, however, there was some effect of population structural change, as shown by the squared line in the right panel of Figure 4.11. For example, out of the 17.6% overall difference in employment rate between the 1935 and 1947 cohorts, 4% was explained by the changes in population composition between the two generations ( $dX$  in equation (4.5)), while 13.6% was due to the non-compositional effects,  $\delta B$ .



**Figure 4.11:** Effects of compositional and behavioral change on employment differences across cohorts

Figure 4.12 further decomposes the total compositional change ( $dX$  in equation (4.5)) into each of the covariates included in the model. None of the changing

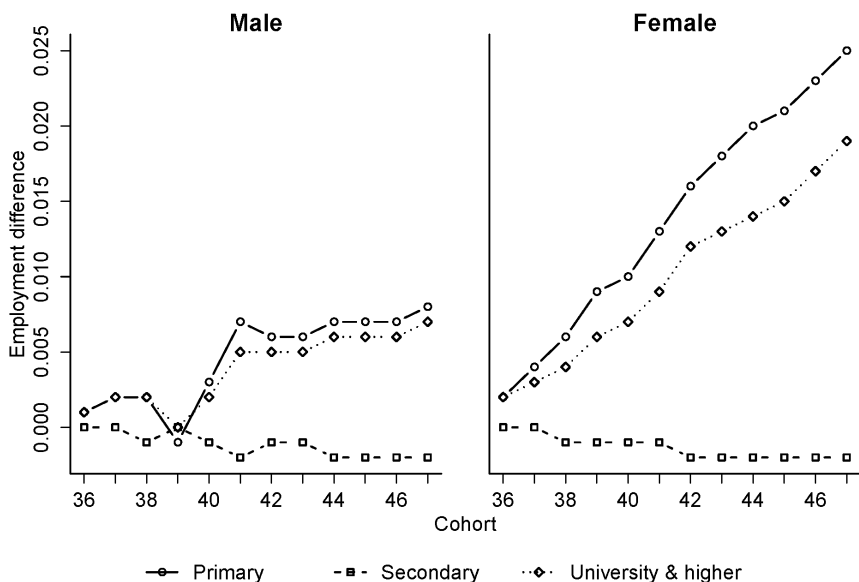
means of covariates contributed to the cohort employment differentials for men. This is not surprising, as we just discussed that the effects of compositional change on the overall cohort trend of employment rate (shown by the squared line in the left panel of Figure 4.11) was essentially zero. However, there were slightly more profound compositional effects for women (shown by the squared line in the right panel of Figure 4.11) which were mainly due to the changing educational composition. This is shown by the black squared line in the right panel of Figure 4.12, which most closely matches the total compositional change (the circled line).



**Figure 4.12:** Decomposing effect of total compositional change on cross-cohort employment differences by covariates

We further decompose the effect of educational composition change on old-age employment by levels of educational attainment. The results are presented in Figure 4.13. The effect of compositional change in education on employment was mainly attributable to two groups; the least educated (shown by the dotted line), and highly educated (shown by the circled line).

Table 4.6 provides a summary of the decomposition results illustrated in Figures



**Figure 4.13:** Decomposing effect of compositional change in education on cross-cohort employment differences by educational attainment

4.11, 4.12, and 4.13. The summary statistics are calculated by taking the average of the  $dY$  and  $dX$  in equation (4.5) across cohorts 1936-1947. In other words, the averages over the rows of Table 4.4 and Table 4.5. The first row in Table 4.6 shows that the average difference in the age 60-64 employment rate between the 1935 and each later-born cohort was 8.9% for men and 9.3% for women. The second row of Table 4.6 suggests that the average effect of the compositional difference on the employment difference between the 1935 and each of the 1936-47 cohorts was negligible for men. However the average employment difference for women was explained more than one-fourth by the average compositional change in the population (2.5% out of 9.3%). Of the 2.5% average contribution of population structural change to the overall employment trend, 2.2% was driven by educational composition change.

**Table 4.6:** Summary of average effects of compositional change on old-age employment

	Male	Female
Avg. dY	0.089	0.093
Avg. dX	0.003	0.025
Age	0.000	0.000
Marital	-0.005	0.000
Education	0.008	0.022
Hospital	0.001	0.001
Birth Country	-0.001	0.001

## 7 Summary and Discussion

Over the past decades, a number of OECD countries have seen their old age population exhibit a reversal pattern of employment, from a greater proportion of early retirees to a greater proportion who remain active workers at age 60+, although the magnitude and the tempo of these changes vary across countries (OECD, 2013). Many argue that the observed reversal was attributable to pension reforms which facilitated the prolongation of working life (Börsch-Supan et al., 2009; Buchholz et al., 2013; Karlström et al., 2008; Komp et al., 2010). The present study contributes to this literature by considering the importance of changes in population composition in the reversing old-age employment, a relation that has seldom been explored in the retirement literature. Our argument is that if highly educated, skilled and healthy workers are more likely to retire later, as shown in previous studies (Börsch-Supan et al., 2009; Buchholz et al., 2013; Glans, 2008; Klevmarken, 2010; Komp et al., 2010; Larsen and Pedersen, 2013; Stenberg and Westerlund, 2013), then the changes in retirement age may have risen due to changes in the population's composition, because the old age workforce might be increasingly better educated and skilled over time.

Our main focus is on the variation in old-age employment across cohorts rather than over time. This is because the major institutional reform in Sweden, the 1994 public pension reform, was implemented during a specific year, but affected differ-

ent birth cohorts disproportionately. Hence, we presume the cohort differences, as shown in Figure 4.1, partly identifies the employment effect of the reform. However, we also argue that cross-cohort differences in old-age employment may be driven by changes in other factors, such as culture, behavior, norms, as well as labor demand. Thus our decomposition analysis essentially examines the relative importance of the changing distribution of the population characteristics and the residual that captures all kinds of non-compositional changes.

The descriptive analysis shows considerable variation in the composition of education across cohorts, but little change in the share of population with good and poor health. The composition of native-immigrant populations do vary across cohorts, but the foreign-born's relative share of the population is small. Therefore, one might expect the changing educational composition of workers might play an important role in determining the reversing cohort trend in old-age employment. Our main findings are summarized as follows:

1. For men, the reversing cohort trend in old-age employment was unaffected by any compositional changes in education, health, and foreign born across cohorts, despite considerable variation in population characteristics, particularly in the share of educational attainment.
2. For women, the changing population structure played a bigger role than for men in shaping the old-age employment trend, although it was not dominant (the compositional change explained 2.5% out of 9.3% average increase in employment rate across cohorts). Out of this 2.5%, the educational composition change accounted for 2.2%, of which about 1% was due to the growing share of the population who had attained university or higher education. The remaining 1.2% of the effect from education came from the declining fraction with primary education.

The regression analyses further suggest that education, health, and country of origin are all important determinants of late-life employment within each cohort. This implies that more coherent and integrated policies are necessary, since the employment differentials across social, demographic, and health strata are large in both economic and statistical terms.

As argued by Harper (2014), public policy in light of population ageing should enable prolonging working life through lifelong training, education, and skills updating, as well as providing improved working conditions for older workers. Such a

view is also mildly supported by our investigation, as our regression analysis shows that higher education elevates the probability of working, and the decomposition analysis suggests that the growing share of university educated, and declining share of primary educated, matter for cross-cohort employment differentials, at least for women. In addition, recent evidence also suggests that education, not only at young ages, but also at mid-age, is important for retaining workers in the labor force (Stenberg and Westerlund, 2013). Therefore, providing education and promoting life-long training programmes are relevant to reduce the inequality in old-age employment.

The last, but not least, note from our analysis is that a considerable share of the older workforce is still available as “unused capacity”. Although the employment rate among healthy workers in the youngest cohort increased to 70% for men and 65% for women, about 20-25% of healthy workers are inactive in the labor market. Such an “unused capacity” deserves further research attention.

One might argue that the amount of “unused capacity” may be driven by our crude measure of health; we treat all individuals not being hospitalized in the previous year as healthy. This measure might not necessarily reflect the true health condition, and, as a result, the “unused capacity” might be exaggerated. This specification may also have led to little cross-cohort variation in health composition, as shown in Figure 4.7, which consequently contributes nothing to the increase in old-age employment. There are two alternative health measures, the length of sickness absence and the use of out-patient care, which may give more variation in the health composition.

However, the former may lead to an endogenous relationship between health and employment, particularly for the older population. For example, individuals with strong pure preference for leisure may have greater incentive to live on sickness benefits, given the generous provision for sick leaves in Sweden. One previous study found that the employment effect of the disability pension reform appears to be crowded out by the increase in the utilization of sick leave benefits (the so-called “communicating vessel effect”) (Karlström et al., 2008). In this case, the duration of sickness might be a subjective measure of health, and the employment effects of health might be exaggerated, a mechanism similar to people who use poor health to justify non-participation in labor activities, the justification hypothesis. Using out-patient care might give more variation in health composition, simply because the use of this service is more frequent than inpatient care. Unfortunately,

the corresponding data in the outpatient care register in Sweden starts from year 2001, which only covers half of the study period. Hence, we used the inpatient care register, mainly the number of days in hospital, as the source of an objective health measure.

We would like to conclude this paper by mentioning some caveats in our analysis and possible extension for future research. Our decomposition analysis is unable to disentangle the relative importance of pension reforms, changes in working norms, preferences, behavior, and/or labor demand in shaping the reversal of old-age employment. These factors are captured by a single residual. Thus, a more comprehensive retirement model and empirical estimation are needed to address the question in more detail.

Furthermore, as mentioned, to understand the existence of the remaining “unused capacity”, one might need to look into the “communicating vessel effect”. That is to quantify the extent to which these healthy, but inactive, workers are bridging the work-retirement transitions through unemployment benefits, sickness benefits, and/or early withdraw of pension benefits.

Finally, our analysis showed large late-life employment differentials across foreign born populations. This sheds light on the importance of investigating older foreign workers and their responses to policy intervention, an area which deserves further research, particularly during an era when a large share of first-generation labor migrants are about to reach pensionable age.

## References

- Albin, M., T. Bodin, and E. Wadensjö (2015). National Report: Sweden. In H. M. Hasselhorn and W. Apt (Eds.), *Understanding Employment Participation of Older Workers*. Berlin Federal Ministry of Labour and Social Affairs.
- Barro, R. J. (1974). Are Government Bonds Net Wealth? *Journal of Political Economy* 82(6), 1095–1117.
- Becker, G. S. (1964). *Human Capital*. New York: Columbia University Press.
- Bengtsson, T. and K. Scott (2011). Population Ageing and the Future of the Swedish Welfare State. *Population and Development Review* 37, Supplement.

- Berkovec, J. and S. Stern (1991). Job Exit Behavior of Older Men. *Econometrica* 59(1), 189–210.
- Bloom, D. E. and D. Canning (2009). Fertility, Female Labor Force Participation, and the Demographic Dividend. *Journal of Economic Growth* 14(2), 79–101.
- Börsch-Supan, A., A. Brugiavini, and E. Croda (2009). The Role of Institutions and Health in European Patterns of Work and Retirement. *Journal of European Social Policy* 19(4), 341–358.
- Buchholz, S., A. Rinklake, and H. P. Blossfeld (2013). Reversing Early Retirement in Germany A Longitudinal Analysis of the Effects of Recent Pension Reforms on the Timing of the Transition to Retirement and on Pension Incomes. *Comparative Population Studies* 38(4).
- Coale, A. J. (1957). How the Age Distribution of A Human Population Is Determined. *Cold Spring Harbor Symposia on Quantitative Biology* 22, 83–89.
- Cotton, J. (1988). On the Decomposition of Wage Differentials. *The Review of Economics and Statistics* 70(2), pp. 236–243.
- Glans, E. (2008, November). Retirement Patterns during the Swedish Pension Reform. Working Paper Series 2008:9, Uppsala University, Department of Economics.
- Grossman, M. (1972). On the Concept of Health Capital and the Demand for Health. *Journal of Political Economy* 80(2), 223–255.
- Gruber, J. and D. Wise (1999). *Social Security and Retirement around the World*. Chicago, IL: The University of Chicago Press.
- Gruber, J. and D. Wise (2004). *Social Security and Retirement around the World: Micro Estimation of Early Retirement Incentives*. Chicago, IL: The University of Chicago Press.
- Hagen, J. (2013, May). A History of the Swedish Pension System. Working Paper Series, Center for Fiscal Studies 2013:7, Uppsala University, Department of Economics.
- Hallberg, D., T. Lindh, G. Öberg, and C. Thulstrup (2011). Intergenerational Redistribution in Sweden's Public and Private Sectors. In R. Lee and A. Mason



(Eds.), *Population Aging and The Generational Economy, A Global Perspective*. Edward Elgar Publishing Limited.

Harper, S. (2014). Economic and Social Implications of Aging Societies. *Science* 346(6209), 587–591.

Helgertz, J. and M. R. Persson (2014). Early Life Conditions and Long-term Sickness Absence during Adulthood - A Longitudinal Study of 9000 Siblings in Sweden. *Social Science & Medicine* 119, 224 – 231.

Heyma, A. (2004). A Structural Dynamic Analysis of Retirement Behaviour in the Netherlands. *Journal of Applied Econometrics* 19(6), 739–759.

Jann, B. (2008). The Blinder-Oaxaca Decomposition for Linear Regression Models. *The Stata Journal* 8(4), 453–479.

Jappelli, T. and F. Modigliani (2005). The Age-Saving Profile and the Life-Cycle Hypothesis. In F. Franco (Ed.), *The Collected Papers of Franco Modigliani*, Volume 6. MIT Press.

Johansson, P., L. Laun, and M. Palme (2014, May). Pathways to Retirement and the Role of Financial Incentives in Sweden. NBER Working Papers 20123, National Bureau of Economic Research.

Karlsson, H. and H. Olsson (2012). Medelpensioneringsalder och Uttradesalder 2011.

Karlström, A., M. Palme, and S. Ingemar (2008). The Employment Effect of Stricter Rules for Eligibility for DI: Evidence from A Natural Experiment in Sweden. *Journal of Public Economics* 92, 2071–2082.

Karlström, A., M. Palme, and I. Svensson (2004). A Dynamic Programming Approach to Model the Retirement Behaviour of Blue-Collar Workers in Sweden. *Journal of Applied Econometrics* 19(6), 795–807.

Klevmarken, A. (2010). Vereforms efter 65 års ålder? En statistisk analys. Report från sociala rådet, Statens Offentliga Utredningar.

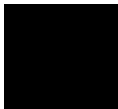
Komp, K., T. Tilburg, and M. B. Groenou (2010). Paid Work between Age 60 and 70 Years in Europe: A Matter of Socio-economic Status? *International Journal of Ageing and Later Life*.

- Konberg, B., E. Palmer, and A. Sunden (2006). The NDC Reform in Sweden: the 1994 Legislation to the Present. In R. Holzmann and E. Palmer (Eds.), *Pension Reform: Issues and Prospects for Non-financial Defined Contribution (NDC) Schemes*. Washington D.C.: The World Bank.
- Larsen, M. and P. Pedersen (2013). To Work, to Retire, or Both? Labor Market Activity after 60. *IZA Journal of European Labor Studies* 2(1).
- Laun, T. and J. Wallenius (2015, July). A Life Cycle Model of Health and Retirement: the Case of Swedish Pension Reform. *Journal of Public Economics* 127, 127–136.
- Lee, R. and R. D. Edwards (2001). The Fiscal Impact of Population Change. In *Seismic Shifts: The Economic Impact of Demographic Change*, Number 46, Boston, pp. 190–219. Federal Reserve Bank of Boston conference Series.
- Lee, R., D. Gretchen, and T. Miller (2011). The Changing Shape of the Economic Life-cycle in the United States, 1960 to 2003. In R. Lee and A. Mason (Eds.), *Population Aging and The Generational Economy, A Global Perspective*, Chapter 15, pp. 313–326. Edward Elgar Publishing Limited.
- Lee, R. D. (1994). The Formal Demography of Population Ageing, Transfer, and the Economic Life Cycle. In L. G. Martin and S. H. Preston (Eds.), *Demography of Ageing*, pp. 8–49. Washington, DC: National Academy Press.
- Lumsdaine, R. L., J. H. Stock, and D. A. Wise (1992). Three Models of Retirement: Computational Complexity versus Predictive Validity. In D. A. Wise (Ed.), *Topics in the Economics of Aging*. University of Chicago Press.
- Macurdy, T. E. (1981). An Empirical Model of Labor Supply in a Life-Cycle Setting. *Journal of Political Economy* 89(6), 1059–85.
- Maestas, N. and J. Zissimopoulos (2010). How Longer Work Lives Ease the Crunch of Population Aging. *Journal of Economic Perspectives* 24(1), 139–60.
- Mason, A. (2005). Demographic Transition and Demographic Dividends in Developed and Developing Countries. In *United Nations Expert Group Meeting on Social and Economic Implications of Changing Population Age Structures, Mexico City*. United Nations.

- Mason, A. and R. Lee (2007). Transfers, Capital, and Consumption over the Demographic Transition. In R. Clark, A. Mason, and N. Ogawa (Eds.), *Population Aging, Intergenerational Transfers and the Macroeconomy*, pp. 128–162. Elgar Press.
- Mason, A. and R. Lee (2011). Population Aging and the Generational Economy: Key Findings. In R. Lee and A. Mason (Eds.), *Population Aging and The Generational Economy, A Global Perspective*, Chapter 1, pp. 3–31. Edward Elgar Publishing Limited.
- McDaniel, S. A. (2003). Toward Disentangling Policy Implications of Economic and Demographic Changes in Canada's Aging Population. *Canadian Public Policy / Analyse de Politiques* 29(4), pp. 491–510.
- Neumark, D. (1988). Employers' Discriminatory Behavior and the Estimation of Wage Discrimination. *The Journal of Human Resources* 23(3), pp. 279–295.
- Oaxaca, R. L. and M. R. Ransom (1994). On Discrimination and the Decomposition of Wage Differentials. *Journal of Econometrics* 61(1), 5 – 21.
- OECD (2013). Pensions at A Glance 2013: OECD and G20 Indicators. *OECD Publishing*.
- Palmer, E. (2000). The Swedish Pension Reform Model : Framework and Issues. Discussion Papers no. 23086, The World Bank.
- Peracchi, F. and F. Welch (1994). Trends in Labor Force Transitions of Older Men and Women. *Journal of Labor Economics* 12(2), pp. 210–242.
- Preston, S. H., P. Heuveline, and M. Guillot (2001). *Demography: Measuring and Modeling Population Processes*. Blackwell Publishing Ltd.
- Preston, S. H., C. Himes, and M. Eggers (1989, Nov). Demographic Conditions Responsible for Population Ageing. *Demography* 26(4), 691–704.
- Qi, H. (2015). Real Wage and Labor Supply in A Quasi Life-Cycle Framework: A Macro Compression by Swedish National Transfer Accounts (1985–2003). *Vienna Yearbook of Population Research* 12.
- Reimers, C. W. (1983). Labor Market Discrimination Against Hispanic and Black Men. *The Review of Economics and Statistics* 65(4), pp. 570–579.

- Settergren, O. (2001). Two Thousand Five Hundred Words on the Swedish Pension Reform. Working Papers no. 2001:1, The National Social Insurance Board.
- Skirbekk, V. (2003). *Age and Individual Productivity: A Literature Survey*. MPIDR.
- Stenberg, A. and O. Westerlund (2013). Education and Retirement: Does University Education at Mid-Age Extend Working Life? *IZA Journal of European Labor Studies* 2(1).
- Stock, J. H. and D. A. Wise (1990). Pensions, the Option Value of Work, and Retirement. *Econometrica* 58(5), 1151–80.
- Sunden, A. (2006). How Much Do People Need to Know about Their Pensions and What Do They Know? In R. Holzmann and E. Palmer (Eds.), *Pension Reform: Issues and Prospects for Non-financial Defined Contribution (NDC) Schemes*. Washington D.C.: The World Bank.
- United Nations (2013). *National Transfer Accounts Manual: Measuring and Analysing the Generational Economy*. New York: United Nations.

## Chapter v





## Chapter 5

# Prolonged Working Life in Sweden - A Result of the Great Pension Reform?

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# Abstract

The mean age at retirement in Sweden increased roughly one month per year between 2000 and 2011 (Karlsson and Olsson, 2012). Empirical studies mostly relate this increase to eligibility requirement changes in the Swedish disability pension, which became increasingly stringent during the 1990s. Few, however, have attributed this increase to the 1994 old-age pension reform, which affected a broad spectrum of older workers. This paper specifically examines whether the rising retirement age was driven by the 1994 pension reform. The key finding is that the reform exerted a significant positive effect on the mean age at retirement for men, yet had little effect for women. For example, the reform raised *de facto* retirement age by 2.4 months for men, but merely 0.6 months for women, among those born in 1944.

JEL Classification: H55, J18, J26

Keywords: Education, Occupation, Pension, Reform, Retirement

## 1 Introduction

The share of the Swedish population aged 65+ doubled over the twentieth century. This demographic development has evolved via declines in both fertility and mortality, as described by the stable population theory (Preston et al., 1989, 2001). However, the initial reduction in deaths, when mortality levels remained high, actually rejuvenated the population, as the individual ageing effect (changes in the life-cycle survival schedule) were outweighed by the growth rate effect (Lee, 1994). Hence, previous population ageing in Sweden was mainly driven by the fertility decline, at least until the late twentieth century (Bengtsson and Scott, 2011; Coale, 1957). The ageing process was beneficial to economic development and the creation of welfare services, as survivors were concentrated at young ages, which, together with fewer children being born, increased the ratio of productive to non-productive population (the demographic support ratio). This phenomenon is commonly referred to as “the first demographic dividend” (Bloom and Canning, 2009; Mason, 2005; Mason and Lee, 2007; United Nations, 2013). However, this dividend has now been turned into a deficit, because continuous improvements in human survival, particularly after age 65, have made the individ-



ual ageing effect dominate the rate of growth effect, and, therefore, contribute to a declining support ratio.

The declining support ratio creates challenges for welfare states. One challenge is the potential threat to the sustainability of public old-age pension system, particularly Defined Benefit Pay As You Go (DB PAYG) systems. The average pension expenditure is expected to grow from 9% to 12% of total GDP between 2010 and 2050 across OECD countries (OECD, 2013). Such growth in pension provision, in a context of population ageing, will result in rising costs per worker to provide benefits to a given age vector of retirees, assuming the length of working life (e.g. between 20 and 65) is fixed (Lee and Edwards, 2001). To counteract this threat, many governments across OECD countries have prioritized pension reform, with the goal of creating incentives for postponing retirement. Recent OECD statistics showed that the average labor market exit age across OECD countries has gradually increased since the early 2000s (OECD, 2013). Some argue that this increase is indeed the result of government interventions, such as restricting early retirement schemes, and/or raising statutory retirement ages (Buchholz et al., 2013; Komp et al., 2010).

Sweden, without exception, has gone through several reforms of the public pension system. In 1991, the government abolished the retirement pathway, whereby disability insurance (hereafter DI) could be utilized for labor market reasons (e.g. due to unemployment). Six years later, DI was further restricted by eliminating favorable rules for workers aged 60-64 (Hagen, 2013). A major reform on the public pension system was introduced in 1994, when the parliament passed legislation of a new pension system. This legislation was to phase out the defined-benefit pay as you go pension system (ATP) with a Notional Defined Contribution pay as you go system (NDC). After these reforms, Sweden, like many other OECD countries, also witnessed an increase in effective mean retirement age after a long-term trend towards early retirement. The average exit age from the labor market conditional on working at age 50 grew from 63 to 64 years old between 2000 and 2011, an increase of about one month per year (Karlsson and Olsson, 2012).

Whilst the majority of retirement studies for Sweden have focused on the effects of disability insurance on retirement (e.g. Johansson et al. (2014); Karlström et al. (2008)), much less attention has been paid to the 1994 old-age pension reform which affected a broader spectrum of older workers. The only study to date which specifically evaluated the impact of the 1994 Swedish old-age pension reform is

Glans (2008), who documented a remarkable decline in the retirement hazard over ages 60-64 among the cohorts most affected by the reform. However, the reduced form estimation on the time to retirement event only captures the differences in hazards between those who are unaffected and those who are more affected by the reform (i.e. cohort differences), which might potentially confound behavioral modifications incentivized by the reform, and preference changes that are independent of the pension reform. This paper contributes to the literature by explicitly incorporating financial incentives in the retirement model in order to distinguish between these two types of behavioral change. Doing this allows us to evaluate the true effect of the Swedish old-age pension reform on labor market exit age. Another advantage of our study is that we use the latest updated register data which covers cohorts younger than those in Glans (2008). This is crucial for understanding the behavioral response to this policy change, as younger cohorts were more affected by the reform.

Our overall aim is to examine the effects of phasing in the NDC pension scheme on the prolongation of working life. The key research question is whether, and to what extent, the rising mean retirement age is a result of the 1994 public pension reform. To address this central question, we first examine the differences in pension entitlements before and after the reform, and quantify the benefit difference between the observed and the counterfactual pension income that older workers would have otherwise been entitled to had the reform not been implemented. Secondly, we incorporate the benefit changes into the retirement model and make inferences regarding the effect of labor and pension income on retirement probabilities. Finally, we evaluate the effects of the reform on working life extension by examining the differences between the observed and the counterfactual average retirement age, assuming the post-reform pension benefit is the same as the pre-reform level.

## **2 The Great Reform in the Swedish Pension System**

Sweden followed a long-term trend towards early retirement until the late-1990s. Some argue that this trend is attributable to the generosity of disability insurance (DI) since the early 1970s. Over the period 1970 to 1991, workers aged 60+ could retire through DI with labor market reasons, such as unemployment, which largely explains the declining labor force participation among the older workers during the

period (Hagen, 2013). During the 1990s, the Swedish government implemented two major reforms concerning DI; first by abolishing the utilization of DI for labor market reasons in 1991, and secondly, by eliminating the favorable rules for workers aged 60-64 in 1997.

The labor supply effects of these DI reforms have been studied by Karlström et al. (2008), who found a positive impact on the labor force participation rate. Moreover, this study also showed large anticipation effects of the reform, due to the fact that the reform was announced two years prior to its implementation. As a result, the transition from unemployment to DI almost doubled, corresponding to about 2% of the labor force between ages 60 and 64, during the year before the reform was implemented. Karlström et al. (2008) argued those who transitioned were mainly the DI applicants aged 60-64 in 1996 (born 1932 to 1936), who believed that they would be eligible for DI under the pre-reform regime, but not under the post-reform regulation. Furthermore, according to Karlström et al. (2008), the application had to be filed before January 1, 1997, meaning the last group who benefited from the favorable rule of DI were those aged 60 on December 31, 1996, the 1936 cohort.

However, the period of investigation in Karlström et al. (2008) ended in 2001, thus further developments in old-age labor supply remain unclear. Some have shown that the average exit age from labor market increased approximately one month per year between 2000 and 2011 (Karlsson and Olsson, 2012). Was such an increase a response to the changes in stringency of DI admission? This question is difficult to answer because the post-DI reform period overlapped with the reform on the general old-age pension system. The new pension system (NDC) proposed in the 1994 old-age pension reform was implemented in 1999 and started paying out benefits in 2001 (Hagen, 2013).

The reformed old-age pension system comprises three main pillars: the universal covered guarantee part, Notional Defined-Contribution Pay-As-You-Go (NDC PAYG) and privately managed fully funded accounts (Palmer, 2000; Hagen, 2013). For the income related PAYG pillar, there was a gradual transition from the ATP to NDC, which was implemented over 16 years. The first recipient of NDC were those born in 1938, whereby one-fifth of their pension was calculated based on the NDC rule, and the remaining four-fifths based on the ATP rule. The NDC part, as a share of the total income related benefit from the public old-age pension, increased by 5 percentage points for each successive cohort up to those born in 1953.

Hence, the pension entitlements for those born in 1954 or later are accounted by a complete conversion of the accumulated pension credits from the ATP into the NDC (Palmer, 2000; Settergren, 2001; Konberg et al., 2006; Hagen, 2013). All benefits will be completely paid from the NDC system by the year 2040 (Sunden, 2006).

The ATP and NDC pension schemes are different in many aspects. The former has a defined benefit feature which has been proven to be unsustainable given the context of demographic ageing, whereas the latter is in the defined contribution spirit, which has the potential for ensuring long-term sustainability. From the individual's perspective, the two systems can be mainly distinguished by two features, the importance of earning history and the divisor for calculating pension benefits. These two factors create the differences between ATP and NDC as they lead to differences in the rate of return.

Under the ATP, only the best 15 years of earnings during the working life are used to calculate one's pension entitlements, whereas, under the NDC, the entire life earnings are taken into account for calculating benefits. This fundamental difference between the two schemes creates stronger incentives for workers to postpone retirement under the NDC system. This is because under the best-15-year rule, workers would not expect any increase in their final pension benefits as the highest earning over the life cycle tends to occur before age 50 (Laun and Wallenius, 2015). However, NDC implies that the entirety of pre-retirement labor income will be relevant for calculating entitlements, thus additional years of earnings at old ages will increase expected benefits. It is also noteworthy that the best-15-year rule in ATP generates significant redistribution from low- to high-income earners and from women to men, simply because the peak of the labor income over the life cycle is typically higher for men and high-income earners. This potentially treats workers with equivalent lifetime earnings, but with inequivalent life-cycle earning profiles, unequally (Laun and Wallenius, 2015). Therefore, NDC addresses this equity issue inherent to ATP by taking full life time earnings into account.

The second important feature that distinguishes NDC from ATP is the divisor to calculate the annuity. The divisor is a function of remaining life expectancy, which is determined by age and cohort, and not by gender and previous earning history. This divisor, however, implies benefit reduction for those participating in the NDC system (i.e. for those born in 1938 or later). As long as life expectancy continues to increase, the younger generation will receive ever decreasing monthly pension

benefits, since the divisor is an increasing function of remaining years of living (Hagen, 2013). Such a mechanism also creates incentives for delaying retirement, because an additional year of working not only gives a one more year contribution to the pension assets, but it also deducts one year of remaining life expectancy from the divisor. This is particularly important for retirement income between ages 60 and 64, since from age 65 workers will be able to claim a guaranteed pension which can potentially top up the monthly pension benefits. Hence, as some have pointed out, the lifetime pension income as a function of retirement age is very flat in ATP, whereas it increases steeply under NDC (Laun and Wallenius, 2015; Palmer, 2000). The effect of retiring at age 66 will be an increase in monthly pensions of about 9 percent, and the effect of retiring at age 67 will result in a nearly 20 percent increase, compared to retiring at age 65 (Konberg et al., 2006).

Having briefly summarized the historical reforms of the DI and old-age pension system, our first conclusion is that to identify the labor supply effects of DI reform and/or the 1994 pension reform is challenging, as these reforms took place simultaneously. Furthermore, as we stressed earlier, previous studies have focused on the effects of disability insurance on retirement (Johansson et al., 2014; Karlström et al., 2008), but much less attention has been paid to the 1994 old-age pension reform which covers a broader spectrum of older workers. Our emphasis in this paper is, therefore, on the effects of the 1994 pension reform on retirement.

To eliminate the effect of DI reform, we condition our sample on those born from 1937 onward, because, as we formerly discussed, the 1937 cohort are identical to all later born in terms of facing the same stringency of the DI eligibility rule. However, they differ from those born in 1938 or later since their old-age pension benefits were completely calculated by ATP rules. Therefore, the remainder of the paper will examine the difference in retirement between the 1937 cohort who were unaffected by the 1994 pension reform, and those born in 1938 or later who were affected.

### 3 A Simple Retirement Model

We assume that the time horizon for each individual to choose between work and retirement starts from age 60. This is because income-related pension benefits are payable from age 60 onwards in the ATP system, and from age 61 onwards in the NDC system. Moreover, the last year of possible employment is assumed to be age

67. This is motivated by the fact that the 2001 Employment Act allows workers to be fully engaged in labor activity up to and including age 67.

Our retirement model is a simplified version of a dynamic programming model. The main assumption we impose is the zero discounting factor. The reason for such simplification is that our analysis is based on the entire population, and the challenge of recursive computation in dynamic programming using such a large sample would be too burdensome. One might argue that this is a strong assumption, as it eliminates forward looking behavior. However, previous empirical evidence has shown that there is no difference in the estimated coefficient signs between the static and dynamic models, only in coefficient sizes. For example, the coefficient estimates in Berkovec and Stern (1991) differed only in magnitudes, and not in signs, across the model with 0 and 0.95 discounting factors. Moreover, empirical evidence in Qi (2015) showed that the inter-temporal substitution behavior was largely outweighed by the intra-temporal substitution behavior among older workers (aged 60+) in Sweden. Such evidence implies that the static assumption in the simplified retirement model might not be so strong, as older workers might become myopic once approaching the end of the life-cycle. Hence, we model individuals' work history as a static choice problem between work and retirement over a discrete and finite time horizon between ages 60 and 67.

### 3.1 Values of Working and Retirement

The choices of work and retirement are modelled in a random utility set up, which conventionally comprises two components, the observed part of the utility and the remaining unobserved proportion of the utility. Hence, in the context of deciding whether to continue working or retire, the utility of the two choices may be expressed by the following two equations, respectively:

$$U_W = V_W + \epsilon_W \quad (5.1)$$

$$U_R = V_R + \epsilon_R \quad (5.2)$$

where,  $V$  denotes the observed utility, and  $\epsilon$  is the unobserved part. Subscripts  $W$  and  $R$  refer to the choices of working and retiring.

It is important to stress that the salient difference between this paper and earlier work with a similar focus, such as Glans (2008), is that we explicitly distinguished working-retiring choice as a function of financial incentives and non-financial

preferences. Such a distinction is crucial for policy evaluations. As mentioned earlier, one of the key goals for pension reforms across many OECD countries is to create incentives for working longer (OECD, 2013). These incentives can only be mediated through the pecuniary value of retirement, but not through the non-pecuniary part. This is because financial incentives to work longer can only be created through adjusting workers' budget constraint (i.e. the pecuniary value), yet seldom by altering individuals' pure preferences. For this, we define the observed value,  $V$  in (5.1) and (5.2), as:

$$V_W = V(Y_W, B_W) + V_W(X) \quad (5.3)$$

$$V_R = V(Y_R, B_R) + V_R(X) \quad (5.4)$$

where,  $Y$  and  $B$  are labor and pension income, respectively.  $X$  is a set of exogenous individual characteristics.

The first term on the right hand side of (5.3) and (5.4) corresponds to the pecuniary value of being in the labor force and retirement, respectively, which is solely determined by labor and pension income. The second term of both equations (5.3) and (5.4) refers to the non-pecuniary value of being in either state. One might interpret this term as the non-financial utility flow.

The value functions in (5.3) and (5.4) are assumed to be a linear combination of all the covariates and the associated parameters. Therefore, (5.3) and (5.4) may be explicitly written as:

$$V_W = \alpha Y_W + \beta B_W + \gamma_W X \quad (5.5)$$

$$V_R = \alpha Y_R + \beta B_R + \gamma_R X \quad (5.6)$$

The first two terms on the right hand side of equations (5.5) and (5.6) constitute the pecuniary values in (5.3) and (5.4). As the covariates in the pecuniary value function vary across choices, the two parameters,  $\alpha$  and  $\beta$ , thus distinguish the marginal utility of labor income from the marginal utility of pension income. The last term on the right hand side of equations (5.5) and (5.6) corresponds to the non-pecuniary values in (5.3) and (5.4). Non-pecuniary value is determined by a set of exogenous socio-demographic individual characteristics, which are constant across the two choices, work and retirement.

### 3.2 Probability of Retiring

The probability of choosing to retire may be simply defined as:

$$\begin{aligned}
 \Pr(R) &= \Pr(U_R > U_W) \\
 &= \Pr(V_R + \epsilon_R > V_W + \epsilon_W) \\
 &= \Pr(V_R - V_W > \epsilon_W - \epsilon_R)
 \end{aligned} \tag{5.7}$$

From (5.7), it is clear that the probability of retiring is the cumulative density function (CDF) of  $\epsilon_W - \epsilon_R$  that is below a certain threshold (i.e. the difference between the value of retiring and working ( $V_R - V_W$ )). Let  $\xi_V$  be the value difference  $V_R - V_W$  and  $\xi_\epsilon$  be the difference of two random errors  $\epsilon_W - \epsilon_R$ , thus the probability in (5.7) may be re-written as:

$$\Pr(R) = \int I(\xi_V > \xi_\epsilon) f(\xi_\epsilon) d\xi_\epsilon \tag{5.8}$$

where,  $I(*)$  indicates whether the argument,  $\xi_V > \xi_\epsilon$ , is true.  $f(*)$  is a density function of  $\xi_\epsilon$ .

Since we have discussed the observed part of utility,  $V$ , the remaining issue to be addressed in order to calculate the probability of retirement is the assumption on the distributions of  $\epsilon_W$ ,  $\epsilon_R$ , as well as  $\xi_\epsilon$ . Because  $\epsilon_W$ ,  $\epsilon_R$ , and  $\xi_\epsilon$  are unobserved, to compute the probability of retiring requires the integration of  $\Pr(R)|\xi_\epsilon$  over all values of  $\xi_\epsilon$  weighted by the density function,  $f(\xi_\epsilon)$ . The integral in (5.8) may be evaluated either by numerical solution or closed form solution. It is well known that the former method is much more computationally intensive than the latter. Therefore, we choose the closed form solution to proceed with our retirement model.

To derive the closed form solution for computing the probabilities of retiring, three assumptions on  $\epsilon_W$  and  $\epsilon_R$  are needed. First, the two errors are independent of each other. Second, both errors are identically distributed. Third, each of the errors follows a Gumbel distribution (Type-I extreme value distribution). The last assumption is motivated by the fact that the difference between the two Gumbel distributed variables follows a logistic distribution. More explicitly, if  $\epsilon_W$  and  $\epsilon_R$  are independently and identically distributed extreme values, then  $f(\xi_\epsilon)$  is a logistic distribution.



Having imposed the above three assumptions on the  $\epsilon$ 's, the probabilities of retiring have closed form corresponding to the logit transformation of the pecuniary and non-pecuniary part of the value functions, as in (5.5) and (5.6). Therefore, the probability of retiring can be expressed as:

$$\Pr(R) = \frac{\exp(V_R)}{\exp(V_W) + \exp(V_R)} \quad (5.9)$$

### 3.3 Model Interpretation

It is well known that, for discrete choice data, the value of each of the choices can only be identified relative to some reference. In the present context, we are only interested in the difference between the values of being retired and remaining in the labor force. We choose the alternative, working, as the base, and therefore, (5.9) may be re-written as:

$$\Pr(R) = \frac{\exp(V_R - V_W)}{1 + \exp(V_R - V_W)} \quad (5.10)$$

From (5.5) and (5.6), the value difference between retiring and working is:

$$V_R - V_W = \alpha(Y_R - Y_W) + \beta(B_R - B_W) + (\gamma_R - \gamma_W)X \quad (5.11)$$

The interpretation for the non-pecuniary value is straightforward, since the exogenous individual characteristics in  $X$  are constant across choices. Thus the term  $\gamma_R - \gamma_W$  may be interpreted as the value of retiring relative to the value of working for fixed values of  $X$ .

The  $\alpha$  and  $\beta$  are coefficients for the alternative specific variables. The ratio of the two coefficients can be interpreted as the marginal rate of substitution. To be more explicit, assuming the level of utility is a constant (or equivalently  $dV = 0$ ), the total differential of the value function can be written as:

$$dV = \alpha dY + \beta dB = 0 \quad (5.12)$$

Rearranging (5.12) yields:

$$\frac{\alpha}{\beta} = - \frac{dB}{dY|_{dV=0}} \quad (5.13)$$

Hence, the ratio of  $\alpha$  to  $\beta$  in (5.13) can be interpreted as the marginal rate of substitution of labor income while working in terms of pension income while retiring. For instance, if  $\frac{\alpha}{\beta} = 0.6$ , and suppose that the expected annual labor income is 100,000 SEK, a worker would choose to retire with the same level of utility if he/she is compensated with at least 60,000 SEK as pension income. In other words, the worker would be willing to forego at most 40,000 SEK of labor income to retire.

## 4 Data

Our analysis relies on data from the Swedish Interdisciplinary Panel (SIP), which contains ample information on individual labor market outcomes, such as income and occupational attainment, as well as socio-demographic and health characteristics. SIP consists of individual level data from several different administrative registers, including the income and taxation registers, the inpatient register and the total population register (RTB). These multiple registers are merged to create a longitudinal database covering roughly 12 million unique individuals born between 1930 and 1980 who resided in Sweden sometime during the period 1968-2013. The database allows for studies examining individuals behavior towards the end of their labor market careers, from a life course perspective.

As we discussed, the DI reform was implemented in 1997. This may have created incentives for early retirement among those who were under the favorable rules of DI. To isolate this potential effect from the old-age pension reform, one needs to ensure the observations in the sample were exposed to identical policy settings, except the old-age pension reform. For this, we extracted data on the cohorts born between 1937 and 1944 from SIP. This is because the oldest cohort born in 1937 was no longer under favorable rule of DI, but were under the identical DI policy setting to all the later born cohorts. Furthermore, this cohort was not affected by the old-age pension reform, thus an ideal reference group.

Another sample selection criterion is that all the individuals are working at age 59 (i.e. they receive only positive labor income, but not any sorts of pension income). Hence, our sample excluded those who claim DI before age 60, but included those who retired on DI between age 60-64. We followed all individuals from age 60 to 67, assuming the entire population is retired at age 67. This is because the 2001

Employment Act implemented in September of the same year allows workers to be fully engaged in labor activity up to and including age 67.

We use labor and pension income information to define retirement. The labor income comprises wages, salaries, sickness benefits, parental benefits, and unemployment benefits. The pension income includes payments received from old-age pension and disability insurance. The retirement age is defined as when the sum of any sorts of pension income exceeds the labor income. This implies that partial retirement is counted as working if the associated retirement income does not exceed income from labor. Furthermore, workers who are unemployed and/or on sick leave are treated as being in the working state, since they are still part of the labor force.

The following two figures describe the basic patterns in our sample. Figure 5.1 compares the survival probability of being in the labor force for the oldest cohort unaffected by the 1994 reform, and for the youngest cohort whose pension benefits were calculated by both ATP and NDC. More specifically, for the youngest cohort, half of their total old-age pension income was derived based on the ATP system, and the remaining half was calculated by NDC rules. The difference between the two survival curves in each panel in Figure 5.1 suggests that the younger cohort remained in the labor market longer than the older cohort. Another important feature is that around 10% of the population remained in the labor force at age 67 for the 1944 birth cohort, while close to 0% were active in the labor market for the 1937 cohort.

To summarize the age patterns of retirement shown in Figure 5.1, we calculated the average effective labor market exit age for each consecutive cohort born between 1937 and 1944, which is illustrated in Figure 5.2. The mean exit age from the labor market exhibits a clear upward trend for each successive cohort for both sexes. This cohort trend coincides with what was shown in Karlsson and Olsson (2012). However, our calculated retirement ages are higher than in Karlsson and Olsson (2012), because our sample conditioned on still being in the labor force at age 59, whereas their sample conditioned on age 50. The difference between the oldest and youngest cohort in average retirement age is 0.47 for men and 0.56 for women. In other words, the shifting age pattern shown in Figure 5.1 implies that those born in 1944 retired on average 5.7 months for men and 6.7 months for women later than those born in 1937 who were unaffected by the pension reform, and whose benefits were entirely calculated based on the ATP rule.

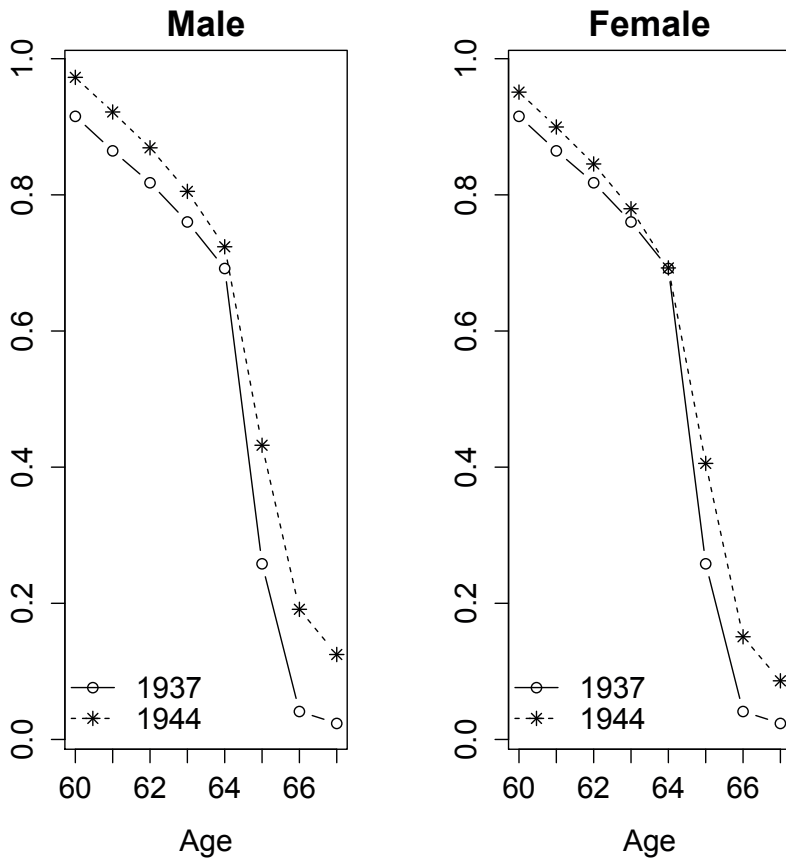


Figure 5.1: Age pattern of probability of remaining in the labor force conditioning on working at age 59

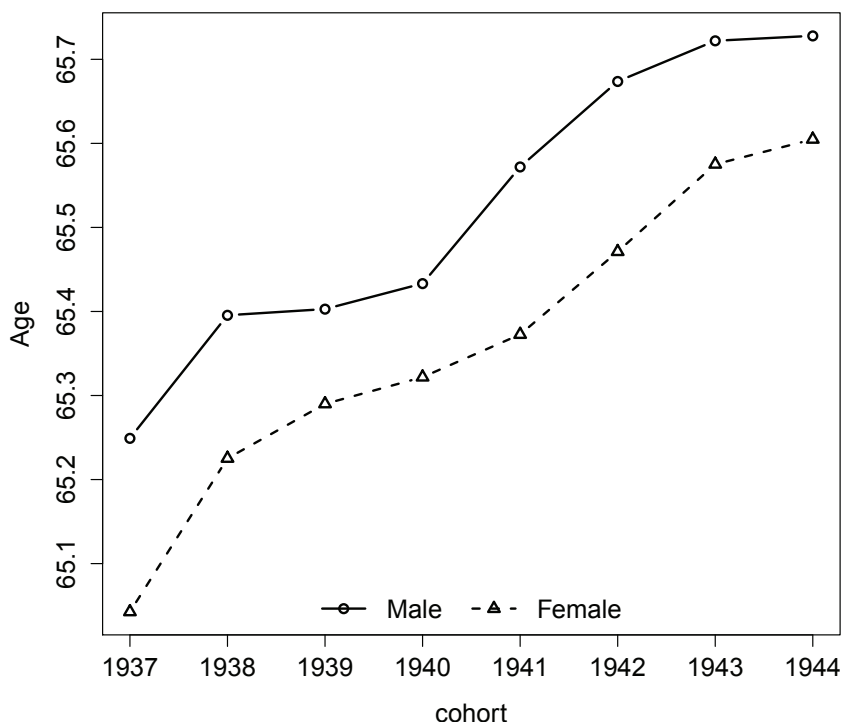


Figure 5.2: Cohort trends in retirement age conditional on working at age 59

## 5 Methods

### 5.1 Missing Data: Labor and Pension Income

To incorporate pecuniary value into the retirement model, as shown in (5.5) and (5.6), we need information of both labor and pension income. However, one problem arises due to missing income data, as some retirees had missing labor income, and alternatively, some workers lacked pension income. To estimate our previously specified retirement model requires imputation of the missing income data. The following briefly illustrates how we overcame this challenge in our analysis.

Labor income was observed for each individual only up to the age prior to the first year of retirement, as workers are assumed to receive no labor income upon exiting the labor force. Hence, the missing labor income during the first year of retirement was imputed by the labor income received during the year before retirement. There is no need to impute missing labor income after the first year of retirement, as observed individuals are censored after the retirement event occurred.

As we mentioned in the data section, pension income came mainly from two sources, disability pension and old-age pension. We did not impute the disability pension if it is missing, and simply replaced missing values with zero. The old-age pension (OA) was imputed by a pension forecasting equation, which was estimated by regressing the observed old-age pension benefits on a number of time-varying and time-constant covariates. The implicit specification may be written as:

$$OA_{i,t} = f(t, c, Z_i, S_{i,t}, \theta) \quad (5.14)$$

where,  $t$  is age.  $c$  is the dummy indicator for each of the birth cohorts.  $Z_i$  is a set of time-constant covariates: sex, education, and country of origin.  $S_{i,t}$  is a set of time-varying covariates: marital status, occupation, and accumulated labor income since age 55 ( $\sum_{i=55}^{t-1} Y(t)$ ).  $\theta$  is a vector of parameters.

We used the estimated coefficients and the observed values of all covariates in equation (5.14) to predict the expected pension (i.e.  $E(OA_{i,t}|t, c, Z_i, S_{i,t}, \theta)$ ). The counter-factual pension was predicted by imposing the cohort variable equal to 1937 (i.e.  $E(OA_{i,t}|t, c = 1937, Z_i, S_{i,t}, \theta)$ ). This essentially eliminated the cohort difference in benefit accounting in order to generate a counter-factual scenario that the 1994 pension reform did not take place.

## 5.2 Estimating Retirement Model

The theoretical retirement model derived previously forms the basis for estimating retirement probabilities. The empirical model corresponding to the theoretical model may be explicitly specified as follows:

$$V_{W,i,t} = \alpha Y_{i,t} + \gamma_W X_{i,t} \quad (5.15)$$

$$V_{R,i,t} = \beta[E(OA_{i,t}|t, c, Z_i, S_{i,t}, \theta) + DI_{i,t}] + \gamma_R X_{i,t} \quad (5.16)$$

where,  $Y_{i,t}$  is observed labor income (for the first year of retirement, we replace  $Y_{i,t} = Y_{i,t-1}$ ).  $E(OA_{i,t}|t, c, Z_i, S_{i,t}, \theta)$  is expected old-age pension income predicted by (5.14).

$DI_{i,t}$  is observed pension income from disability insurance.  $X_{i,t}$  is a set of covariates: age, cohort, sex, education, marital status, occupation, and country of origin.

The retirement model was estimated by logistic regression with maximum likelihood estimation. Given the value functions of working and retiring in (5.15) and (5.16), the probability of retiring is therefore:

$$\Pr(R_{i,t}) = \frac{\exp(V_{R,i,t} - V_{W,i,t})}{1 + \exp(V_{R,i,t} - V_{W,i,t})} \quad (5.17)$$

### 5.3 Predicting Retirement Probability

To evaluate the effects of pension reform on prolonging working life, we predicted the potential retirement outcomes based on our estimated retirement model, given the two scenarios of pension benefits (with and without reform), respectively. The scenario with the reform is essentially the predicted probability given the values of retiring and working determined by all the covariates as observed. Let  $\hat{p}$  be such a predicted probability, thus:

$$\hat{p}_{i,t} = \Pr\{R_{i,t} | V_{W,i,t}(Y_{i,t}, X_{i,t}, \alpha, \gamma_W), \\ V_{R,i,t}(E(OA_{i,t} | t, c, Z_i, S_{i,t}, \theta), DI_{i,t}, X_{i,t}, \beta, \gamma_R)\} \quad (5.18)$$

The scenario of without reform is the probability conditional on the values of retiring and working determined by all the covariates as observed except the expected old-age pension benefits. The cohort variable in (5.16) in this scenario is imposed by  $c = 1937$ . Doing this allows for estimating what the value of retiring, as well as the retirement probability, would have been had the pension income for all cohorts been calculated based on the pre-reform accounting rule, ATP. Let  $p^*$  be such a probability, therefore:

$$p_{i,t}^* = \Pr\{R_{i,t} | V_{W,i,t}(Y_{i,t}, X_{i,t}, \alpha, \gamma_W), \\ V_{R,i,t}(E(OA_{i,t} | t, c = 1937, Z_i, S_{i,t}, \theta), DI_{i,t}, X_{i,t}, \beta, \gamma_R)\} \quad (5.19)$$

To examine the statistical significance of the effects of pension reform on retirement, we also calculated the confidence intervals associated with  $\hat{p}_{i,t}$  and  $p_{i,t}^*$ . These intervals were calculated by:

$$CI_{\Pr(R_{i,t})} = \frac{\exp(\hat{\xi}_{V_{i,t}} \pm 1.96\sigma_{\xi_{V_{i,t}}})}{1 + \exp(\hat{\xi}_{V_{i,t}} \pm 1.96\sigma_{\xi_{V_{i,t}}})} \quad (5.20)$$

where,  $\hat{\xi}_{V_{i,t}} = \hat{V}_{R,i,t} - \hat{V}_{W,i,t}$ .  $\hat{V}_{R,i,t}$  and  $\hat{V}_{W,i,t}$  are the linear prediction of value of retiring and working using (5.16) and (5.15), respectively.  $\sigma_{\xi_{V_{i,t}}}$  is the standard errors of  $\xi_{V_{i,t}}$ .

The standard errors of  $\xi_{V_{i,t}}$  were estimated by:

$$\sigma_{\xi_{V_{i,t}}} = \sqrt{g'_{i,t}(-H)^{-1}g_{i,t}} \quad (5.21)$$

where,  $g_{i,t}$  is the gradient and  $H$  is the Hessian matrix; they were retrieved from the maximum likelihood estimation.

## 5.4 Calculating Mean Retirement Age

We used the potential retirement probabilities,  $\hat{p}$  and  $p^*$ , as well as their confidence intervals to calculate the average effective age of labor market exit in the economy with and without the old-age pension reform, respectively. The two mean retirement ages were calculated using the method of dynamic exit age indicator in Vogler-Ludwig and Dull (2008). The derivation is briefly presented as the following. Let  $\hat{p}_{i,t}$  be the probability of retiring for an individual at age  $t$ , which is predicted by our retirement model, equation (5.17). The probability of remaining in the labor force at age  $t$  is defined as the overall probability of staying in the labor force from some starting age  $t_0$  up to age  $t - 1$  (Vogler-Ludwig and Dull, 2008). In the present context, we assume  $t_0 = 59$ , and this probability may be written as:

$$p_{i,t}^s = \prod_{i=59}^{t-1} (1 - \hat{p}_{i,t}) \quad (5.22)$$

The probability of exiting the labor force at age  $t$  is then the probability of retiring at age  $t$  (i.e.  $\hat{p}_{i,t}$ ), given the overall probability of remaining in the labor force up to age  $t - 1$  (i.e.  $p_{i,t}^s$ ). The average effective labor market exit age is then computed as the sum of ages weighted by the probability of exiting the labor force. The age range in our case is assumed to be between 59 and 67. Therefore, the average exit age may be explicitly written as:

$$e_i = \sum_{i=59}^{67} \hat{p}_{i,t} \times p_{i,t}^s \times t \quad (5.23)$$



Equation (5.23) was applied to calculate the predicted and counter-factual mean exit age with 95% confidence intervals using  $\hat{p}_{i,t}$ ,  $p_{i,t}^*$ , and the corresponding confidence intervals of the two probabilities. The effect of the gradual phasing in of NDC on prolongation of working life is therefore the difference between the average retirement age calculated by  $\hat{p}_{i,t}$  and  $p_{i,t}^*$ . More explicitly:

$$dE(e) = E(e|\hat{p}_{i,t}) - E(e|p_{i,t}^*) \quad (5.24)$$

## 6 Results

This section reports and discusses our major findings of the analysis. We start by showing the differences in the age profiles of pension income across cohorts, both observed ( $OA_{i,t}$ ) and predicted pension ( $E(OA_{i,t}|t, c, Z_i, S_{i,t}, \theta)$ ) using equation (5.14). We then show the simulated counter-factual pension income assuming all cohorts belonging to the ATP system, which is computed by imposing  $c = 1937$  in (5.14). More explicitly, the counter-factual pension income is  $E(OA_{i,t}|t, c = 1937, Z_i, S_{i,t}, \theta)$ . The predicted pension income  $E(OA_{i,t}|t, c, Z_i, S_{i,t}, \theta)$  is used for estimating the retirement model, and the coefficient estimates and model fit are illustrated in the later part of this section. Finally, the effects of the pension reform on retirement age are quantified and reported.

### 6.1 Predicted and Counter-Factual Pension

Figure 5.3 depicts the cohort differences in pension income. All the data on pension benefits were adjusted for inflation to 2011 price levels. The black lines in Figure 5.3 are the observed and predicted pension incomes for men, and the dark grey lines are for women. The first thing to note is that our pension equation fits the observed age profiles of benefits extremely well. This is not surprising as we controlled for age and cohort dummies, as well as their interaction, in the pension equation.

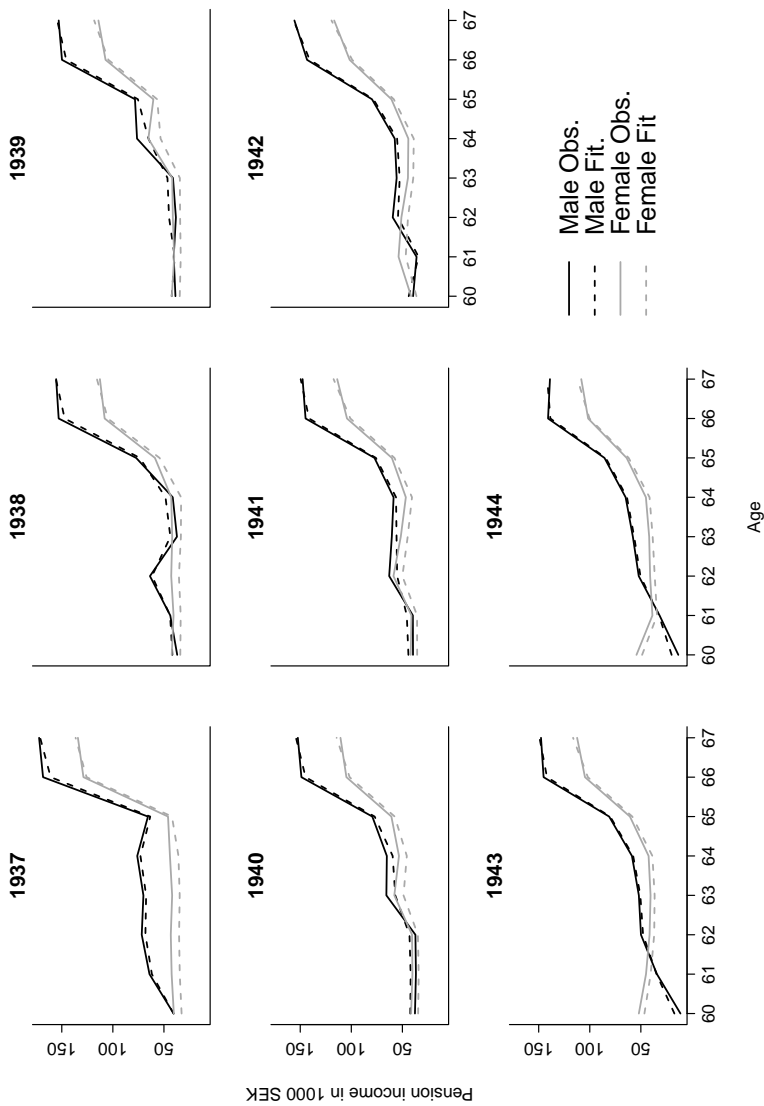
The second important note is that, within each cohort, gender differences in pension entitlements are considerable, as indicated by the discrepancies between the black and grey lines. However, such discrepancies are much more profound within the 1937 cohort than all younger ones. This is mainly due to the differences in the benefit accounting between the ATP and NDC system. The 1937 cohort was the last birth cohort who fully belonged to the ATP system, thus the best-15-year rule

applied to calculate their full benefits. As we mentioned earlier, the 15-best-year rule generated significant redistribution from low- to high-income earners and from women to men, because the peak of the life-cycle earning profile is higher for men and high-income earners. Therefore, the benefit differences are the greatest for the 1937 cohort in Figure 5.3. As the younger cohorts became more attached to the NDC system, such gender differences diminished.

The third noteworthy feature in Figure 5.3 is that the benefits between age 60 and 65 were nearly flat for the 1937 cohort who belonged to the ATP system, but became a steeper increasing function of age for later born, particularly among the last two birth cohorts, whose benefits were 45% and 50% derived from NDC, respectively. This is in line with Laun and Wallenius (2015) who argued that the pension benefits over age were very flat in the old system, but increased much more steeply as a function of age in the new system. The steep growth curve of pension income for younger cohorts is also associated with the divisor in benefit accounting in NDC.

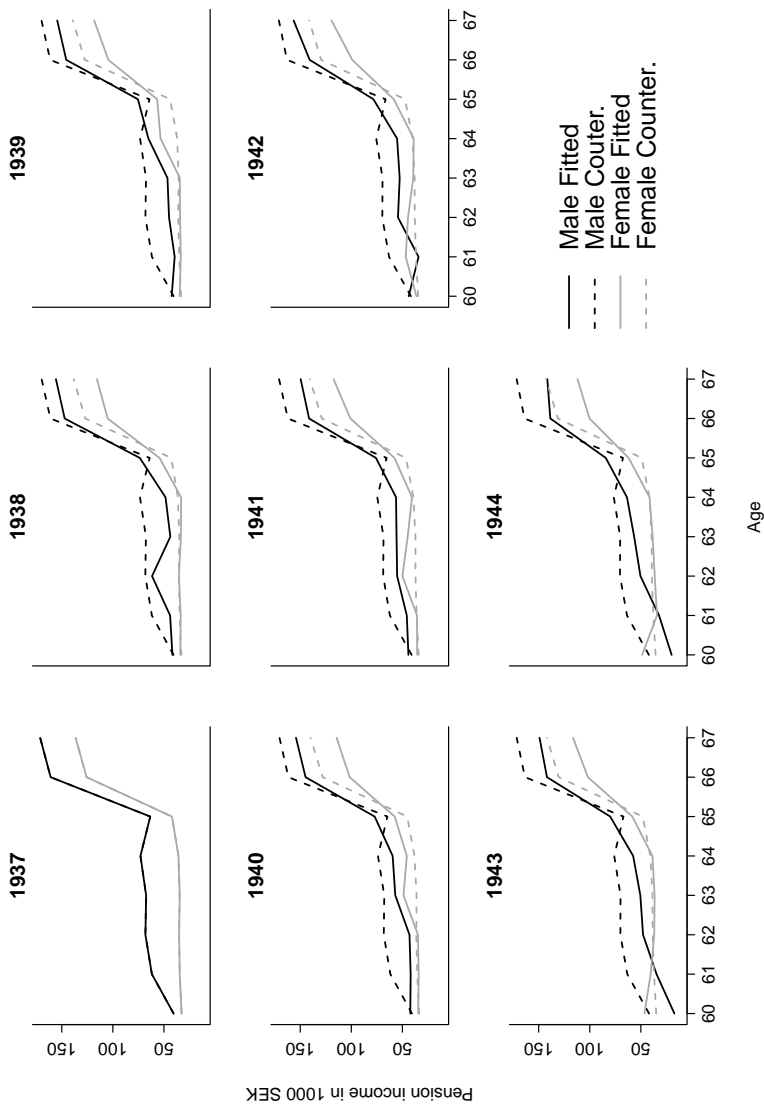
As we stressed earlier, one important feature distinguishing NDC from ATP is the divisor to calculate the annuity. The divisor is a function of remaining life expectancy which is determined by age and cohort, not by gender and previous earning history. This divisor, however, implies benefit reduction for those who participated in the NDC system (for those born in 1938 or later). As long as life expectancy increases, the younger generation will receive ever decreasing monthly pension benefits since the divisor is an increasing function of remaining years of living (Hagen, 2013). This is particularly important for retirement income between ages 60 and 64, since from age 65 workers will be able to claim guaranteed pension, which can potentially top up monthly pension benefits. Therefore, the growth curves in pension income between age 60 and 65 for the two youngest cohorts are much steeper than for their older counterparts.

Figure 5.4 shows the difference between the predicted and counter-factual pension incomes. For the counter-factual, shown by the dash lines in Figure 5.4, it is assumed that all later born cohorts expected to receive the same benefit level as the 1937 cohort. That is every one received 100% ATP pension, and thus the benefits over age would be flat compared to the NDC pension. The difference between the dash lines and the solid lines reflects the amount of pension reduction due to the 1994 pension reform.



**Figure 5.3:** Observed and predicted pension income in 1000 SEK.

Note: observed is the mean of  $OA_{i,t}$ , and predicted is the mean of  $E(OA_{i,t}|t, c, Z_i, S_{i,t}, \theta)$ .



**Figure 5.4:** Predicted and counter-factual pension income in 1000 SEK.

Note: Predicted is the mean of  $E(OA_{i,t}|t, c, Z_i, S_{i,t}, \theta)$ , and counter-factual is the mean of  $E(OA_{i,t}|t, c = 1937, Z_i, S_{i,t}, \theta)$ .

Two features are worth noting in Figure 5.4. First, the reform resulted in much greater benefit reduction for men than women, as the difference between the dash and solid lines is larger for men. In fact, over age 60-65, women gained somewhat in benefits from the reform. Such differences in benefit reduction reflect the difference between ATP and NDC in benefit accounting. As discussed earlier, the best-15-year rule in ATP generated the redistribution from women to men, whereas NDC mitigated such unequal redistribution. The consequence is, as shown in Figure 5.4, that men lost more in pension entitlements than women over the reform. This is because NDC reversed the redistribution flow from low- to high-income earners compared to the old system.

The second important note from Figure 5.4 is that the benefit reduction for men, depicted by the black dash and solid lines, implies that for those more attached to NDC, were they to have retired at the same age under the ATP system, the implied pension income would have been much lower, a finding in line with the argument in Laun and Wallenius (2015).

## 6.2 Retirement Model Estimates

We estimated the retirement model by alternative-specific logistic regression. The estimation is a two-step process. In the first step, we only included individual-specific covariates, the  $X_{i,t}$  in (5.15) and (5.16). Therefore, the model is a reduced form estimation of retirement probabilities, which can be estimated by standard logistic regression.

We added pecuniary variables, both labor and pension, into the model in the second step. That is the model specification as shown in (5.15) and (5.16). The labor and pension income coefficients correspond to  $\alpha$  and  $\beta$ , respectively. They represent the pecuniary value change with respect to the change in each unit of labor income while working and in each unit of pension benefits while retiring. For example, the coefficients reported in the third and fourth columns in Table 1 can be interpreted as an increase in 100,000 SEK from labor income would increase the pecuniary value of working by 1.3 SEK for men and 2.2 SEK for women. The same amount increase in pension income would raise the value of retiring by 3.9 and 4.3 SEK for men and women, respectively.

**Table 5.1:** Model Estimates for Equation (5.17) by Logistic Regression

VARIABLES	Choice: Retire			
	Men	Women	Men	Women
Constant	-2.717***	-2.907***	-1.762***	-2.359***
Labor			0.000013***	0.000022***
Pension			0.000039***	0.000043***
Primary			Reference	
Secondary	-0.019***	-0.049***	-0.064***	0.012
University+	-0.341***	-0.338***	0.011	0.055***
Managerial			Reference	
Service	0.217***	0.099***	0.209***	-0.115***
Manual	0.196***	0.333***	0.162***	-0.043***
Marital	-0.095***	0.026***	-0.253***	0.564***
0 Hosp			Reference	
1 Hosp	0.282***	0.321***	0.110***	0.102***
2 Hosp	0.644***	0.810***	0.402***	0.354***
Age	yes	yes	yes	yes
Cohort	yes	yes	yes	yes
Age-cohort	yes	yes	yes	yes
Country of Origin	yes	yes	yes	yes
Observations	1,781,701	1,661,793	1,781,701	1,661,793
R <sup>2</sup>	0.275	0.269	0.540	0.575
Log Likelihood	-561,960	-552,564	-356,571	-321,700

Significance: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

By taking the ratio of the two coefficients, as shown in (5.13), we get the estimate of the marginal rate of substitution between labor and pension income. The implied marginal rate of substitution by  $\alpha$  and  $\beta$  is 0.33 for men and 0.51 for women. This means that men would choose to retire if their pension entitlement exceeded 33%

of the expected labor income, while the respective figure for women was 51%. In other words, men were willing to forego 18% more labor income than women to exit the labor market.

All the coefficient estimates for the individual-specific covariates,  $X$  in (5.15) and (5.16), may be interpreted as the relative non-pecuniary value of retirement to working. It is noteworthy that the estimates of the individual-specific covariates in the reduced-form estimation (the first and second columns) are substantially different than in the model with income variables (the third and fourth columns), in terms of the direction and/or the magnitude of the coefficients. For example, highly educated workers have substantially lower relative value of retiring to working, compared to those with secondary and primary education, in the reduced-form model. This relationship, however, was reversed in the model that controls for labor and pension income, whereby workers with university or higher degrees were more prone to retirement than those who only attained secondary and primary education. Low-skilled service and manual workers tended to be more likely to retire than high-skilled management and white-collar workers in the reduced form, whereas this relation was reversed for women when pecuniary values were taken into account. Women with low-skilled occupations became more reluctant to retire than high-skilled workers. The only individual-specific covariate whose sign was persistently in line with expectations across models are marital status, and number of hospital admissions during the previous year.

Discrepancies in coefficients between the reduced-form and income model estimates, particularly for education and occupation, highlight the difference between this study and Glans (2008). We distinguished between pecuniary and non-pecuniary values of retirement. The socio-economic differences in retirement probabilities estimated by reduced form models do not necessarily reflect the differences in pure preferences for work and retirement, the preference that is independent of financial incentives. For instance, many studies have documented that the highly educated are less likely to retire than those with lower education levels. Our results provide new insights, showing that these educational differences are not necessarily due to the differences in pure preferences, but rather driven by differences in pecuniary values of retirement. This lends support to some theoretical reasoning for why higher-educated retire later. For example, educated people work more years because their skill premium might result in higher pay (Maestas and Zissimopoulos, 2010; Peracchi and Welch, 1994). Such a premium may, in turn, increase the opportunity cost of retirement, and therefore retain older

workers in the labor force. The highly educated may also start their career later than the lesser-educated, and thus more working years may compensate the loss of pension entitlements due to years spent in education (McDaniel, 2003). Thus the main conclusion from our regression results is that the decision to retire was mostly being driven by money, the pecuniary value of prolonging working life.

A final note relating to Table 5.1 regards the explanatory power of the variation in income to the variation in retirement probabilities. As both the McFadden R-square and the log-likelihood values indicate, the income model fits the data much better than the reduced-form model.

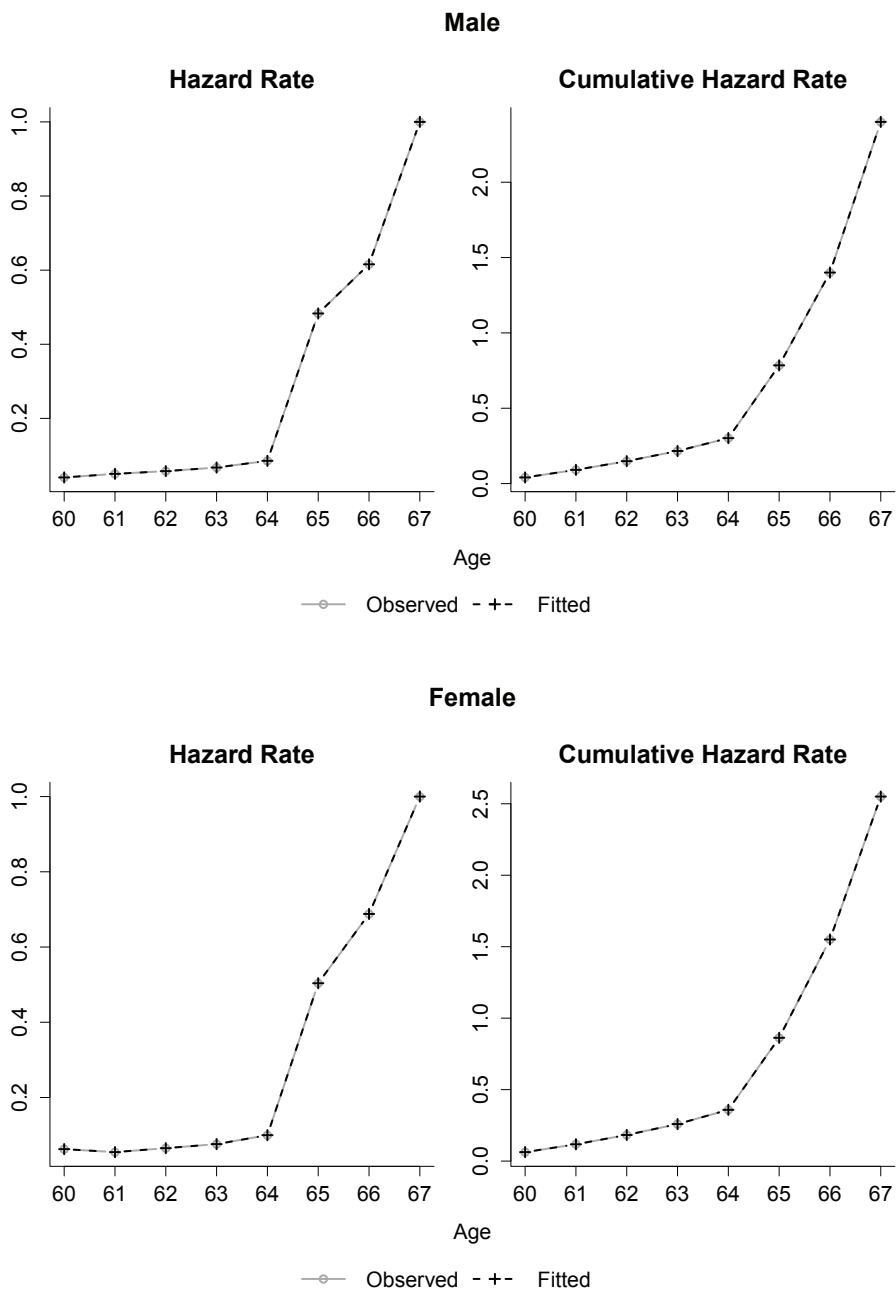
### **6.3 Model Fit**

As we stressed earlier, our main purpose in this paper is to evaluate the effects of the 1994 pension reform on labor market exits. This requires comparing the retirement patterns conditional on the pension income as it was observed and on the counterfactual pension income if ATP was not phased out by NDC. For this, the model fit of the retirement probabilities is extremely important, as the valid comparison relies on good replication of the retirement patterns by the model we specified. Figure 5.5 presents the observed and the predicted retirement hazard based on the model estimates in the third and fourth columns in Table 5.1. The Figure suggests that the model fits the observed age pattern of retirement hazard extremely well for both men and women. Such good fit is mainly due to the control for age dummies.

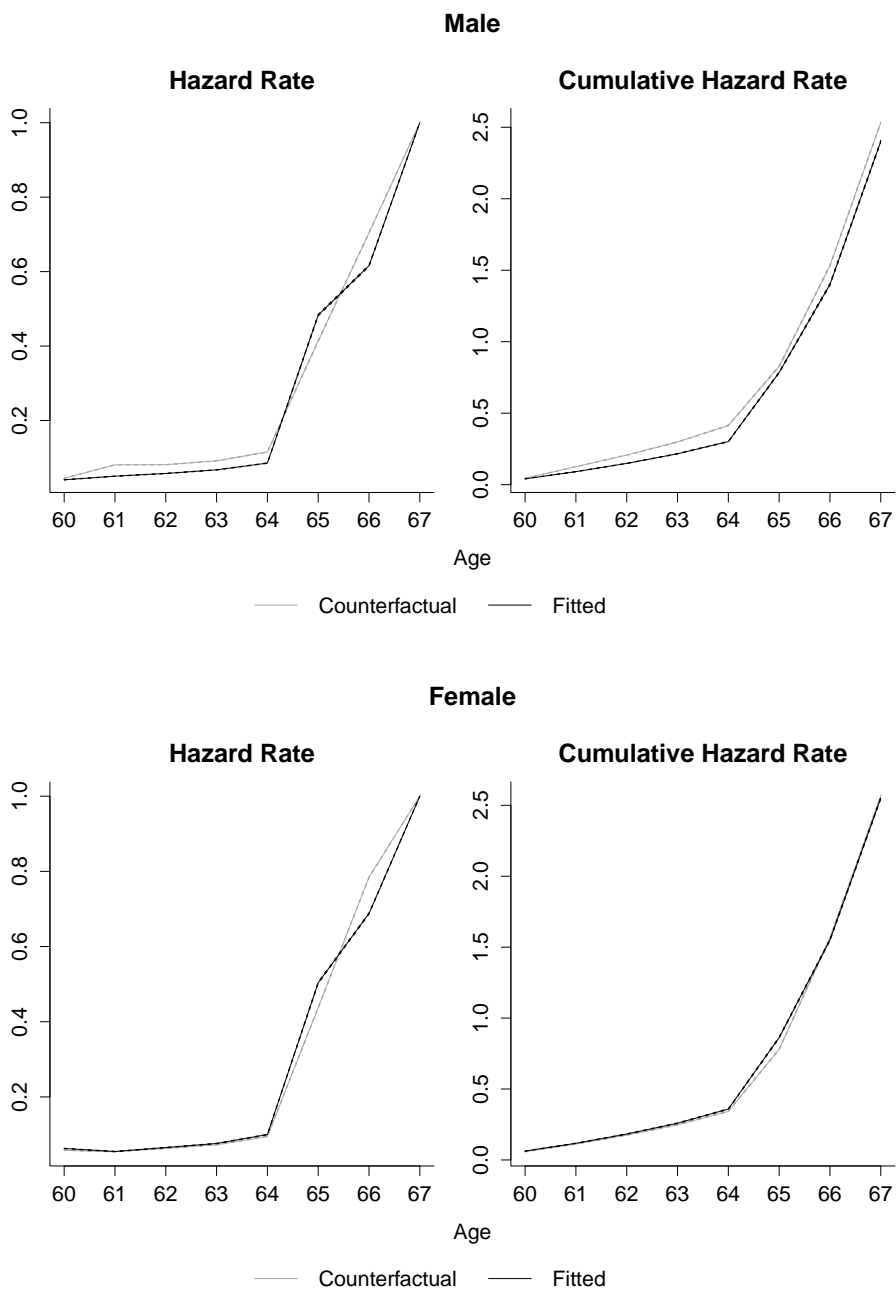
### **6.4 The Effects of NDC on Retirement Hazard**

Figure 5.6 compares the predicted hazard and cumulative hazard rates of retirement (shown by the black solid line) with the counter-factual assuming there were no cohort differences in pension benefit accounting (shown by the dark grey solid line). The dash lines along with the solid lines are 95% confidence intervals.





**Figure 5.5:** Observed and predicted retirement hazard



**Figure 5.6:** Predicted and counterfactual retirement hazard

The difference between the dark grey line and the black line in Figure 5.6 reflects the effects of phasing out the ATP by NDC in the 1994 pension reform on the retirement hazard. The most important feature in Figure 5.6 is that the reform effect was stronger for men than women. In particular, the switch from ATP to NDC gave no difference in retirement hazard rates for women aged 60-64, but a statistically significant difference for men. The reform lowered the retirement hazard rate at age 66 for both sexes.

The overall effect of the reform on the retirement hazard between ages 60-67 is more clearly revealed by the cumulative hazard rate, on the right hand side panels in Figure 5.6. The counter-factual cumulative hazard rate of retirement is constantly higher than the predicted rate for men, while essentially no difference exists for women. Most importantly, the effects on male retirement risk are statistically significant at 95% confidence level, as the confidence bands barely overlap one other.

The reason for such differences between men and women is straightforward. As we already illustrated in Figure 5.4, there were profound benefit reductions for men due to switching from ATP to NDC, but slight gains for women, at least between ages 60-65. This, as one might expect, may translate into disproportional effects on the retirement behavior between men and women. As it clearly stands out in the left panel of Figure 5.6, the effect was more or less equally distributed between men and women aged 65-67, whereas it was unevenly distributed prior to age 65.

## 6.5 The Effect of NDC on Retirement Age

We calculated the mean effective labor market exit age using (5.23) as a summary of the age-specific retirement rates shown in Figure 5.6. We did this for each of the cohorts and calculated the exit age with 95% confidence intervals associated with the predicted and counterfactual retirement probabilities,  $\hat{p}$  and  $p^*$ , respectively. The effect of pension reform on retirement age is the difference between the mean age at labor market exit implied by the predicted and counterfactual retirement probabilities, as per equation (5.24). Figure 5.7 illustrates the difference in average retirement age between the actual and the counterfactual scenarios. The solid line represents the retirement age implied by the predicted probabilities ( $\hat{p}$ ) and the dash line represents the retirement age implied by the counterfactual probabilities ( $p^*$ ).

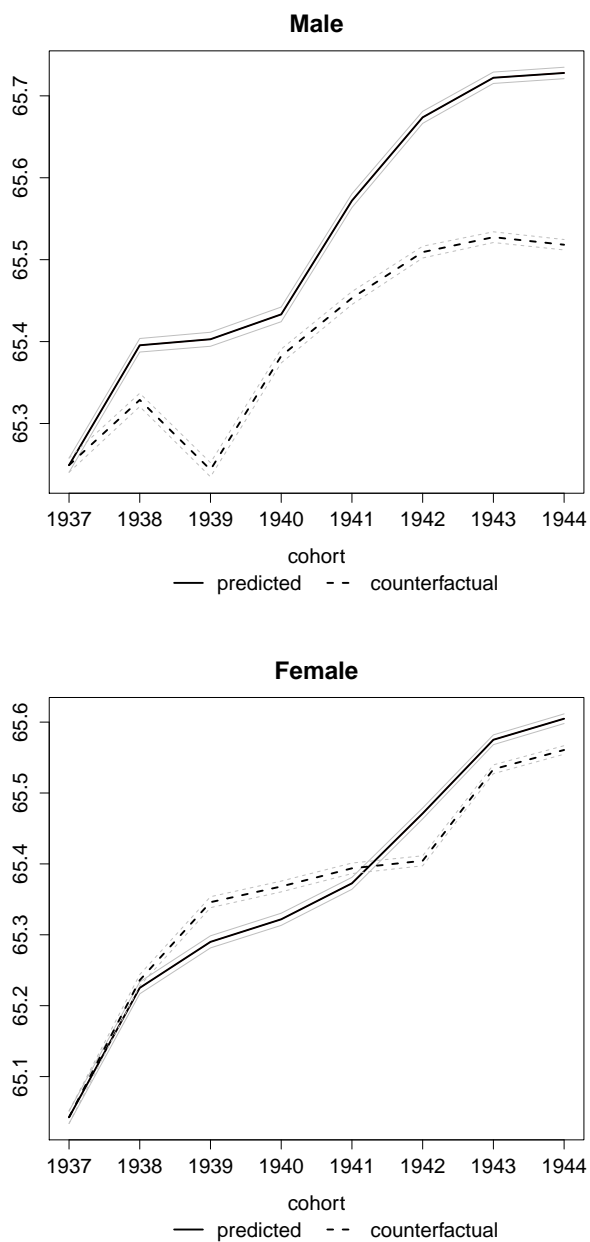


Figure 5.7: Effect of NDC on Average Labor Market Exit Age over Cohorts

The retirement age for men and women exhibits an upward cohort trend in Figure 5.2, as was the case in Karlsson and Olsson (2012); however, the underlying causes appear to be different between sexes in Figure 5.7. For men, the growth in labor market exit age across cohorts seems largely driven by the 1994 pension reform, as the difference between the predicted solid line and the counter-factual dash line is large. The difference also increases over cohorts, which makes intuitive sense because NDC was gradually phased in across these transitional cohorts. As discussed earlier, the transition from ATP to NDC was implemented over 16 years. The first recipients from NDC were those born in 1938, one-fifth of whose pension was calculated based on the NDC rule, and four-fifths based on the ATP rule. The NDC part, as a share of the total income-related benefit from the public old-age pension, increased by 5 percent for each successive cohort up to those born in 1953. Hence, as we can see from the upper panel in Figure 5.7, the effects of the reform on the retirement age was greater for younger cohorts because they were more attached to the NDC pension system, which created stronger incentives to work longer. For example, the mean labor market exit age for the 1944 cohort was 65.73, while it would have been 65.52 if they fully belonged to ATP. This implies that, for this particular cohort, their working lives were prolonged by 0.2 years (or equivalently 2.4 months) on average solely due to the pension reform.

For women, however, the reform effect on the retirement age was much less profound than for men. Taking the youngest female cohort as an example, the mean retirement age was 65.6, while the counterfactual exit age is 65.55. That means the effect of the reform on the retirement age for women born in 1944 was merely 0.05 years, or 0.6 month. In fact, the positive effect of the reform emerged only among those born in 1942 and later. For earlier born cohorts, the reform actually exerted a negative effect on the mean retirement age, and such an adverse impact was statistically significant for the 1939 and 1940 cohorts. However, this negative effect might not be unexpected. As shown in Figure 5.4, the expected pension benefits for women born in 1939 and 1940 prior to age 65 were substantially higher than the counter-factual benefits, which accordingly elevated the value of retirement relative to work, as well as the probability of retiring. As a result, the average age at retirement was lower than it otherwise would have been had the reform not occurred.

In general, the small and opposite effect of reform on female mean retirement age suggests that the upward cohort trend may have been driven by other factors which are independent of economic incentives. In other words, women's average

labor market exit age would have been increasing anyway even though the reform was not in place. For men, however, the increasing mean retirement age across cohorts was largely due to the changing financial incentives mediated by the gradual phasing in of NDC.

## 6.6 The Effect of NDC on the “New Labor Market”

To date, we have presented our results in terms of the average impact of the 1994 pension reform on retirement age. The effects of policy change on potentially vulnerable groups (the so-called “new labor market”) are currently of great interest to researchers and policy makers. To contribute to this discussion, we decompose the average impact of the reform by education and occupation, and address the question of whether various socio-economic groups responded differently to the gradual phasing in of NDC.

Figure 5.8 illustrates the effect of the pension reform on the retirement age by educational attainment. The first insight from Figure 5.8 is that those with a university or higher degree retired at higher ages than those who only finished primary and secondary education. As shown by the predicted cohort trend in retirement age (the solid lines), the average labor market exit age for workers with university+ education was higher than with primary and secondary education, for both genders.

The second insight from Figure 5.8 is that the cohort trend was largely explained by the gradual phasing in of NDC for men, as the difference between the predicted and counterfactual retirement age (the solid vs. dash lines) is profound. This difference persists across all educational groups, meaning that the pension reform created incentives for working more years to more or less the same extent, among all male workers, regardless of educational attainment.

However, the overall reform effect appears much more moderate among women, as the differences between the solid and the dash lines are smaller in the lower panel than the upper panel of Figure 5.8. As just discussed for the cohort trend illustrated in Figure 5.7, the reform did not exert any significant effect on retirement age until the 1942 cohort for women. This appears to be true across all the three educational groups. However, the incentives for late retirement were stronger among those with university+ than with primary and secondary education, as the difference between the predicted and counter-factual mean retirement age is larger for the highest educated, compared to the other education groups among those born in

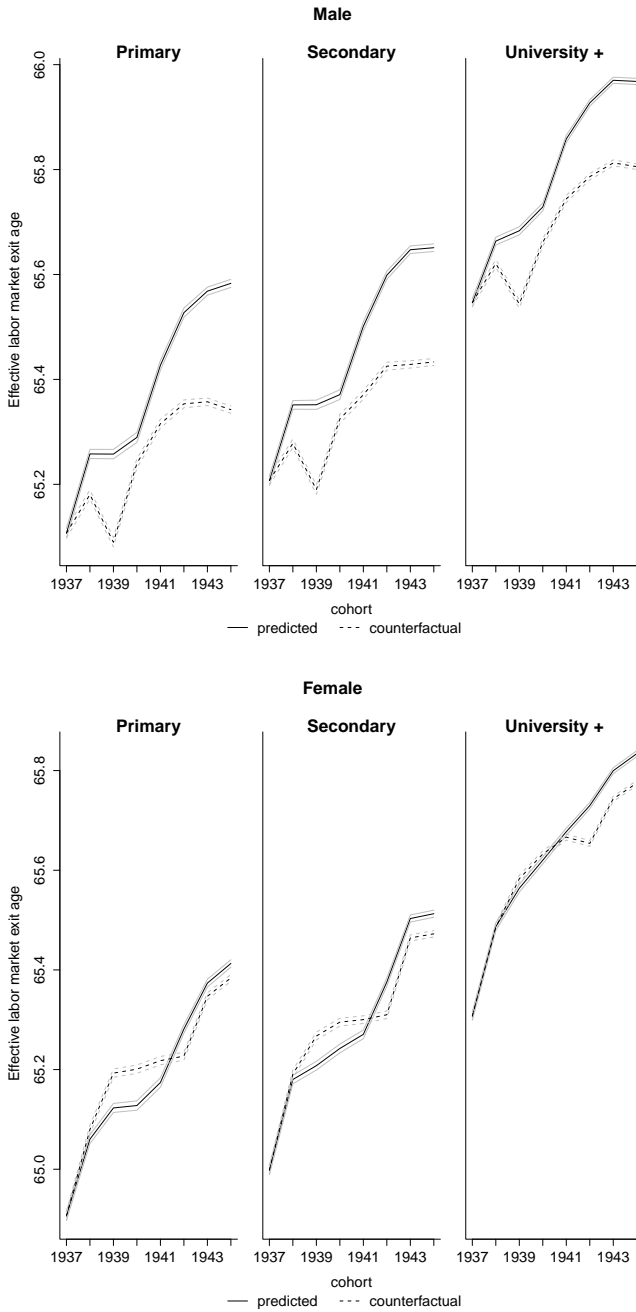
1942 and later.

Figure 5.9 distinguishes the reform effects on the retirement age by high- and low-skilled occupation. The picture is similar to the educational differences shown in Figure 5.8. Male workers were more responsive to the gradual phasing in of NDC than female workers. Among women, high-skilled management and white-collar workers were incentivized the most by the reform across all three occupational groups.

The last, but not least, note from Figures 5.8 and 5.9 is that the negative effect of the reform on retirement age for women, as shown in the lower panel of Figure 5.7, was mainly driven by female workers with primary and secondary education, and with low-skilled occupations. This finding helps us to identify the new labor market effects of the policy amendments with greater precision. There are two explanations for such different responses to the reform among the vulnerable population. First, as discussed earlier, NDC reversed the redistribution of income from low- to high-income earners, which originally existed in ATP. This, in turn, increased the benefits for those low-income earners who were less educated and worked in low-skill occupations. As a result, the reform actually elevated their value and probability of retiring, and reduced their mean retirement age. The second reason might arise from the demand side of the labor market. It might be that the lesser-educated and low-skilled had limited opportunities to prolong their working lives, and therefore responded unexpectedly to the pension reform. However, the second explanation is speculative as our model was not designed for examining any demand-side impact on retirement age.

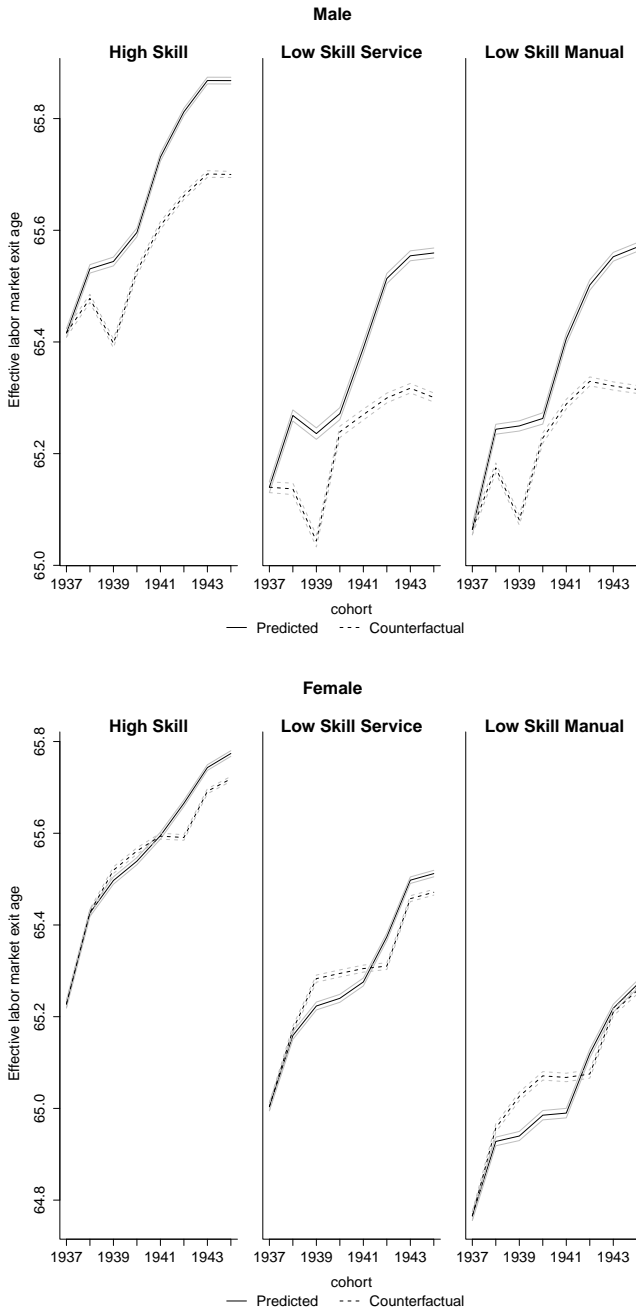
## 7 Conclusion

Sweden has witnessed an increase in the average age at labor market exit for more than a decade. Many have attributed this increase to the government's efforts in reforming disability insurance (DI) over the 1990s (Karlström et al., 2008; Johansson et al., 2014). Our aim in this paper is to complement the relatively scarce literature on the effects of the 1994 general old-age public pension reform on retirement age.



**Figure 5.8: Effect of NDC on Average Labor Market Exit Age by Educational Attainment**





**Figure 5.9: Effect of NDC on Average Labor Market Exit Age by Occupation**

The only previous study examining this reform effect conducted reduced-form survival analysis on time to retirement. Our analysis, by incorporating financial incentives, distinguished between pecuniary and non-pecuniary values of retirement. Such a distinction is of great importance for evaluating the impact of policy amendments, because government interventions aimed at promoting longer working lives can only be accomplished by altering workers' pecuniary value of retirement by adjusting their budget constraints. Non-pecuniary values, such as pure preferences for work and retirement, are hardly influenced by policy. The central question is, therefore, whether the observed increase in retirement age is a result of the gradual phasing in of the NDC pension scheme introduced by the 1994 pension reform.

The 1994 reform imposed a substantial benefit reduction for older male workers, but to a much less extent for female workers, at least among those aged 60-65. This is because of the difference in benefit accounting rules between the pre-reform and post-reform pension schemes. The NDC system replaced the best-15-year rule in the old ATP system by lifetime earnings history as an accounting method for calculating the monthly pension income, which reversed the redistribution flow from low- to high-income earners, as well as from women to men in the old system.

Our alternative-specific logistic regression estimates showed that men were willing to forego more labor income than women in order to retire. This implies that the opportunity cost for men to receive pension while not working was greater, as men's potential labor earnings were higher. Our regression analysis further showed that the pure preference on retirement, independent of pension income, was very different than what one might expect from reduced-form estimations. In particular, we found highly educated and high-skilled female workers were more willing to retire after controlling for financial incentives.

Using information on the benefit difference between the NDC and ATP pension schemes, as well as the estimated pure preference and financial incentives for retirement, we examined the effects of the 1994 pension reform on retirement age. Our main finding is that older male workers were more responsive to the policy amendment than female. The mean exit age from the labor market for the 1944 cohort (the most affected group by the reform in our study sample) increased by 2.4 months as a result of the phased in NDC pension system. However, for women who born in 1944, the effect of the reform on the average retirement age was merely 0.6 months. In other words, women's observed retirement age across

cohorts increased regardless of the switch from ATP to NDC.

Finally, our analysis also showed socio-economic differences in response to the gradual phasing in of NDC. The responsiveness to the reform was large for men regardless of their educational attainment and their occupational skill level. For women, however, the response to the pension reform was only statistically significant among those born in 1942 or later. In addition, the effects on the mean retirement age were greatest among those with a university or higher degree, and who worked in a high-skilled occupation, while negative effects emerged among women who were less educated and skilled.

## References

- Bengtsson, T. and K. Scott (2011). Population Ageing and the Future of the Swedish Welfare State. *Population and Development Review* 37, Supplement.
- Berkovec, J. and S. Stern (1991). Job Exit Behavior of Older Men. *Econometrica* 59(1), 189–210.
- Bloom, D. E. and D. Canning (2009). Fertility, Female Labor Force Participation, and the Demographic Dividend. *Journal of Economic Growth* 14(2), 79–101.
- Buchholz, S., A. Rinklake, and H. P. Blossfeld (2013). Reversing Early Retirement in Germany A Longitudinal Analysis of the Effects of Recent Pension Reforms on the Timing of the Transition to Retirement and on Pension Incomes. *Comparative Population Studies* 38(4).
- Coale, A. J. (1957). How the Age Distribution of A Human Population Is Determined. *Cold Spring Harbor Symposia on Quantitative Biology* 22, 83–89.
- Glans, E. (2008, November). Retirement Patterns during the Swedish Pension Reform. Working Paper Series 2008:9, Uppsala University, Department of Economics.
- Hagen, J. (2013, May). A History of the Swedish Pension System. Working Paper Series, Center for Fiscal Studies 2013:7, Uppsala University, Department of Economics.

- Johansson, P., L. Laun, and M. Palme (2014, May). Pathways to Retirement and the Role of Financial Incentives in Sweden. NBER Working Papers 20123, National Bureau of Economic Research.
- Karlsson, H. and H. Olsson (2012). Medelpensioneringsalder och Uttradesalder 2011.
- Karlström, A., M. Palme, and S. Ingemar (2008). The Employment Effect of Stricter Rules for Eligibility for DI: Evidence from A Natural Experiment in Sweden. *Journal of Public Economics* 92, 2071–2082.
- Komp, K., T. Tilburg, and M. B. Groenou (2010). Paid Work between Age 60 and 70 Years in Europe: A Matter of Socio-economic Status? *International Journal of Ageing and Later Life*.
- Konberg, B., E. Palmer, and A. Sunden (2006). The NDC Reform in Sweden: the 1994 Legislation to the Present. In R. Holzmann and E. Palmer (Eds.), *Pension Reform: Issues and Prospects for Non-financial Defined Contribution (NDC) Schemes*. Washington D.C.: The World Bank.
- Laun, T. and J. Wallenius (2015, July). A Life Cycle Model of Health and Retirement: the Case of Swedish Pension Reform. *Journal of Public Economics* 127, 127–136.
- Lee, R. and R. D. Edwards (2001). The Fiscal Impact of Population Change. In *Seismic Shifts: The Economic Impact of Demographic Change*, Number 46, Boston, pp. 190–219. Federal Reserve Bank of Boston conference Series.
- Lee, R. D. (1994). The Formal Demography of Population Ageing, Transfer, and the Economic Life Cycle. In L. G. Martin and S. H. Preston (Eds.), *Demography of Ageing*, pp. 8–49. Washington, DC: National Academy Press.
- Maestas, N. and J. Zissimopoulos (2010). How Longer Work Lives Ease the Crunch of Population Ageing. *Journal of Economic Perspectives* 24(1), 139–60.
- Mason, A. (2005). Demographic Transition and Demographic Dividends in Developed and Developing Countries. In *United Nations Expert Group Meeting on Social and Economic Implications of Changing Population Age Structures, Mexico City*. United Nations.

- Mason, A. and R. Lee (2007). Transfers, Capital, and Consumption over the Demographic Transition. In R. Clark, A. Mason, and N. Ogawa (Eds.), *Population Aging, Intergenerational Transfers and the Macroeconomy*, pp. 128–162. Elgar Press.
- McDaniel, S. A. (2003). Toward Disentangling Policy Implications of Economic and Demographic Changes in Canada's Aging Population. *Canadian Public Policy / Analyse de Politiques* 29(4), pp. 491–510.
- OECD (2013). Pensions at A Glance 2013: OECD and G20 Indicators. *OECD Publishing*.
- Palmer, E. (2000). The Swedish Pension Reform Model : Framework and Issues. Discussion Papers no. 23086, The World Bank.
- Peracchi, F. and F. Welch (1994). Trends in Labor Force Transitions of Older Men and Women. *Journal of Labor Economics* 12(2), pp. 210–242.
- Preston, S. H., P. Heuveline, and M. Guillot (2001). *Demography: Measuring and Modeling Population Processes*. Blackwell Publishing Ltd.
- Preston, S. H., C. Himes, and M. Eggers (1989, Nov). Demographic Conditions Responsible for Population Ageing. *Demography* 26(4), 691–704.
- Qi, H. (2015). Real Wage and Labor Supply in A Quasi Life-Cycle Framework: A Macro Compression by Swedish National Transfer Accounts (1985–2003). *Viena Yearbook of Population Research* 12.
- Settergren, O. (2001). Two Thousand Five Hundred Words on the Swedish Pension Reform. Working Papers no. 2001:1, The National Social Insurance Board.
- Sunden, A. (2006). How Much Do People Need to Know about Their Pensions and What Do They Know? In R. Holzmann and E. Palmer (Eds.), *Pension Reform: Issues and Prospects for Non-financial Defined Contribution (NDC) Schemes*. Washington D.C.: The World Bank.
- United Nations (2013). *National Transfer Accounts Manual: Measuring and Analysing the Generational Economy*. New York: United Nations.
- Vogler-Ludwig, K. and N. Dull (2008). Analysis of the Average Exit Age from the Labour Force. Report, European Commission.



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# Haodong Qi

## Live Longer, Work Longer?

Evidence from Sweden's Ageing  
Population

Sweden's elderly population is growing, propelled by a continuous decline in old-age mortality, while coupled with a persistent replacement level fertility. This changing age structure increases the per worker cost of providing a given age-vector of per capita benefits, encompassing costs for pensions, health care, and all other type of old-age welfare services, which presents a looming challenge for the welfare state to sustain its social transfer system. Options for tackling this daunting challenge, such as increasing fertility and immigration levels, cutting benefits and growing public debts, present numerous obstacles, thus discussion of policy options has shifted the focus towards extending working life. This book contributes to this ongoing policy discussion by exploring the recent trends in labor supply, and investigating the underlying mechanisms driving these trends. The results of this work illustrate a recent trend of prolonging working life in Sweden, whereby average labor income has increased at older ages, and younger cohorts have increasingly postponed their retirement. While these changes are uniform across individuals of different sexes, occupations, and educational levels, the underlying mechanisms appear different. These micro mechanisms may have myriad implications concerning aggregate economic support for the ageing Swedish population. In this regard, the findings in this book are relevant inputs for assessing the welfare consequences of population ageing and deriving evidence-based policy options.

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