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FOREWORD

Increasing life expectancy has been one of the key drivers for pension reforms. In many countries period-specific life expectancy for a newborn has risen by more than two years over a decade. As a consequence, the number of people expected to live very long will be larger than expected in the future. In Finland, the old-age dependency ratio, currently at 27 percent, is prognosed to increase to 45 percent in 2050. A major issue for pension policies is the division of time between employment and retirement.

This report is the final report from a partnership project between the Finnish Centre for Pensions and Markstat Consultancy. The research project has employed Finnish Labour Force Survey data for the measurement in working careers. The aim of the project was to evaluate the length and development of working careers in different age groups, for men and women and different educational levels. This report presents the main results, with an emphasis on methodological and measurement issues, and was written by adjunct professor Markku Nurminen (PhD [Stat.], DrPH [Epid.]). The project involves another publication on working careers and their development that is published in Finnish.

Mikko Kautto
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ABSTRACT

Working-life expectancy is the expected number of working years remaining in one's life. This report estimates expected times in employment, unemployment and outside the labor force.

The research employs a modern statistical method. The multistate life table approach first estimates age- and year-specific probabilities of being in the different labor market states by stochastic regression modeling. Updated estimates of the probabilities, and subsequently of the expectancies, are given for the Statistics Finland's Labour Force Survey data of Finnish men and women aged 15–64 years in the period 2000–2010, along with mortality figures. Further, model-based predictions are projected for the years 2011–2015.

According to results, the length of working lives in Finland has extended favorably in the 2000s, and the trend is forecast to continue up to 2015 under the provision of economic equilibrium.

ABSTRAKTI

Työajanodote on tunnusluku, joka ilmaisee tietynikäisen henkilön jäljellä olevan ajan työelämässä. Tämä tutkimus käsittelee työllisenä oloajan odotteen, työttömänä oloajan odotteen, ja työvoiman ulkopuolella oloajan odotteen arviointia ja mittaamista työikäisessä väestössä.

Tutkimusmenetelmänä sovellettiin monitilaista regressiomallia. Tutkimusaineistona käytettiin Tilastokeskuksen työvoimatutkimuksen otannan tietoja henkilöiden lukumääristä työmarkkina-aseman mukaan sekä tietoja kuolleisuudesta Suomessa vuosina 2000–2010.

Tutkimuksessa laskettiin aineistoon sovitettujen estimointiyhtälöiden avulla ikä- ja kalenterivuosittaiset todennäköisyydet olla ansiotyössä, työttömänä tai työvoiman ulkopuolella. Todennäköisyyksistä johdettiin integroimalla odotteet 15–64-vuotialle suomalaisille miehille ja naisille vuosina 2000–2010. Odotteiden ennustemalliin perustuvat arvioinnit projisoitiin vuosille 2011–2015.

Tulosten mukaan työurat ovat pidentyneet. Työelämässä oloaikojen kestot ovat kehittyneet Suomessa myönteisesti 2000-luvulla ja pidentymisen ennustetaan jatkuvan vuoteen 2015 asti olettaen, ettei talouskehityksessä tapahdu suuria muutoksia.

EXECUTIVE SUMMARY

Working-life expectancy is the expected number of working years remaining in one's life at a particular age. This report is concerned with its estimation jointly with the expected times spent in the related states of unemployment and outside the labor force.

This research employs a modern statistical method, which has previously been applied to Finnish data from 1980 to 2001. The multistate life table approach first estimates age- and year-specific probabilities of being in the different labor market states by stochastic regression modeling. Updated estimates of the probabilities, and subsequently of the expectancies, are given for the Statistics Finland's Labour Force Survey data of Finnish men and women aged 15–64 years in the period 2000–2010, along with mortality figures. Further, model-based predictions are projected for the years 2011–2015.

According to the results, a general development toward longer working careers is evident. During the past decade, the expected future employment time increased in all age groups and for both genders. In 2010, the estimated average length of working career up to age 64 was 34.6 (95% confidence interval, 34.3–34.8) years for 15-year-old males, while it tailed at 34.0 (33.6–34.4) years for females of the same age. There was an increase of 10 percentage points or more in the working-life expectancies in the study period for females starting already at age 30 and for males from age 45 on. The female working-life expectancies at ages 40 years and above surpassed the respective male figures from 2008 onwards.

Based on the predicted durations of 15-year-old persons' working life expectancies, the working careers could continue to grow: for males by one year to 35.6 (90% prediction interval, 34.8–36.4) years; for females by nearly a year and a half to 35.4 (35.3–35.5) years. The gender gap in the length of working careers would diminish further. The female working-life expectancies for ages 35 years and above is predicted to overtake the respective male figure by year 2015.

The results on educational differences support the anticipation that younger and better-educated cohorts are able to prolong their working lives as they grow older. There were conspicuous differences in the working-life expectancies between persons with tertiary *vs.* primary level of educational attainment.

The length of working lives in Finland has extended favorably in the 2000s, and the trend is forecast to continue up to 2015 under the provision of economic equilibrium.

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Suvi Pohjoisaho, Publications Assistant of the Finnish Centre for Pensions, transformed the manuscript into a publication.

Statistics Finland made available the aggregated Labour Force Survey data on population labour market states and mortality figures.

CONTENTS

1 Introduction

Population aging confronts all developed countries, and a variety of strategies have been undertaken to address it. In Finland, like in many other countries, extending the time spent in employment over the life course has been put forward as a key measure to adjust to the increasing longevity of the population. Demographic change is not a looming crisis of the future – it faces us already. Economic challenges come about when the increasing number of people in advanced ages and the younger generation supporting them cause the growth in society's consumption needs to outpace the upsurge in its productive capacity.

In Finland, population aging will be very rapid during the next two decades, and many preparatory measures have been decided. Prolonging working life is an essential element of a successful policy aimed at complying with the concerns confronting Finland. However, measurement of the length of working careers is not yet a standard practice. Thus it is important to use accurate measures to quantify the working-life expectancies. This study contributes to the current debates on working careers by presenting an overview of the trends and differentials in the expected duration of future employment time – *Working-Life Expectancy* – of the Finnish working-age population throughout the years 2000–2015.

The Finnish Centre for Pensions (FCP) is devoting more research resources to monitoring working careers. The present study is a continuation of a project conducted by the research department of the FCP. The preliminary results were published in a Working Paper (Nurminen 2011). This research report focuses on changes over time in the expectancies of being in the states of employed, unemployed or economically inactive, on changes in the age-specific patterns of employment, and on differences between population sub-groups classified by gender and educational attainment. The purpose is to draw a general picture of trends and differentials in employment across working-age years in the Finnish labor market in the last decade.

The four major demographic determinants that shorten working careers in the Finnish workforce include a delayed start of employment due to extended duration of education, unemployment, disability, and, premature retirement. Lengthening the working careers has become to be regarded as a possible solution to the economic problems of the public sector due to the rapid population aging in Finland (European Commission 2009). It is argued that if people continued working longer, revenue from taxation would increase, and austerity measures could be avoided. Basically, the extension of working careers determines the rise in employment rate. Roughly, it has been estimated that extending the working life from 35 to 40 years would mean a rise in the employment rate from 68 percent to 77 percent (Kiander 2010). An assertion is that work careers can only grow longer if new workplaces spring up in enterprises. In 2011 the employment rate was 68.6 percent and the prediction for 2014 is 69.4 percent (Ministry of Finance 2012).

The strongest arguments in favor of the need for lengthening working careers are economical and arise from the intertwined perspectives of public finances and national economy. In the long term, increasing longevity is likely to increase the economical old-age dependency ratio, and the anticipated change is most brisk between 2010 and 2030 (*e.g*. Risku *et al.* 2012). The growing percentage of the elderly population is projected to increase the public expenditure on health and social services for the elderly. This poses a challenge to the sustainability of public finances, particularly if the size of the future workforce turns out be insufficient to sustain a reasonably assenting economic growth (Ministry of Finance 2010). The deterioration of the dependency ratio may be counteracted by increasing the time spent in employment and thereby extending the average length of working careers. The analyzed time series data on working-life expectancy reported in this study serves to screen the development in Finland in this respect.

Changes to employment pension schemes are among the policy measures that have been implemented as incentives to extend working lives. A recent analysis shows that, unlike in many other countries (OECD 2011), the sustainability of the employment pensions has been strengthened in Finland by the measures taken to date (Vaittinen and Vanne 2012). The changes include measures targeted at cohorts approaching the pensionable age and measures linking the pension accrual more closely than before to an individual's whole employment history. The changes correspond to the policy target of extending working lives but they have increased the significance of working career length also from the point of view of the individual. The length of working life counts at an individual level in terms of securing adequate future pension income and because the sources of alternative social security have been restricted and degraded for those below the pensionable age.

Working age is conventionally taken to extend from 15 to 74 years. In our analysis we opted for the age span of 15 to 64 years for two reasons. First, in Finland, employment at ages above the chosen upper age limit is rare and an essential part of the average years worked occurs between the ages of 15 and 64.

In recent years, the employment of the oldest has increased consistently, but in 2011 the employment rate for those aged 65–69 was still just around twelve percent (Lehto 2012; Järnefelt 2010). The upward trend in the employment of the oldest is certainly important and deserves the attention of further research. However, our second and even more important reason to confine the analysis to persons under 65 years was that, in addition to the working-life expectancies, we also wanted to examine the expectancies of times spent unemployed or being economically inactive, thereby adding to the understanding of the changes in the working-life expectancies. In Finnish labor markets, the number of unemployed persons aged 65 and above is practically nil. To uphold the study design with all three labor market states − employed, unemployed and economically inactive – the exclusion of the age groups at and above 65 was deemed meaningful.

There are differences between population sub-groups in terms of the anticipated employment patterns and the length of working-life. These differences are significant to society both in the sense of individual-level risks and chances as well as due to the related social implications and in the way they support or hinder the realization of longer average working lives. Therefore we report both the development of and the differences in the working-life expectancy according to key socio-demographic characteristics, gender and educational attainment.

Yet another perspective to extending working lives is the question of how employment patterns change over time. If working-life expectancy improves, is it a result of the increase in employment through all ages and years or is it confined to specific age groups and particular calendar years? This report sheds light on the matter in Finland by examining the estimated employment probabilities and their changes across the ages of 15–64 and the years 2000–2010.

To calculate the employment probabilities and to integrate the working-life expectancies and related expectancies we applied a multistate (multinomial) logistic regression to aggregated frequency data (see Davis *et al*. 2001). Statistics Finland's Labour Force Survey data, based on random samples, and annual statistics on fatalities, were used to obtain the numbers of individuals in the four states of employed, unemployed, economically inactive, and deceased.

Our approach to estimating working-life expectancy differs from the traditional method in many fundamental facets. First, although we also use data from the life tables, we estimate the working-life expectancies jointly for multiple years throughout the study period 2000–2010, rather than carry out separate estimations for each year. Second, we base our analysis of birth cohort datasets on a large-sample regression model fitted to a multistate life table instead of a period (current) life table calculated from annual prevalence rates. As labor force participation rates transform over time, these trends are built in more informatively in the multistate life table than in the prevalence life table. Finally, a major advantage of the stochastic approach is that it allows the placement of probability intervals (confidence or prediction intervals) on the expectancies.

In short, the objectives of the present study are the following:

1. To describe the trends in the working-life expectancies and related expectancies over the period 2000 to 2010 and across the age span of 15 to 64 years, using a cohort life table method under a multistate regression model.
2. To analyze how the changes in the working-life expectancy are interrelated to those in the expected times of being unemployed and economically inactive.
3. To compare the development and the differentials of the expectancies between subpopulations classified by gender and educational attainment.
4. To forecast the progress of working-life expectancies up to year 2015.

2 Measures of working-life length

In this section, we discuss the attributes of working-life expectancy in comparison with some other approaches of measuring the length of working life as well as the definitions and historical trends of the alternative measures. Working age conventionally extends from 15 to 74 years. As already mentioned, we opted for the age span 15 to 64 years (50 age groups) in our analysis.

The measurement of the duration of employment time is not a simple matter. In reviewing the alternative employment activity measures, Hytti (2009) discussed the relative advantages and limitations of the retirement exit age (*i.e.* the average age of withdrawal from the labor market) *versus* active-life expectancy. Hytti pointed out that the labor market exit age reacts rapidly and in the correct direction to the changes in the transitions to retirement. However, the exit age measure ignores the cumulative experience up to the present time. By comparison, the expectancy was said to react slowly to the changes in labor market participation and the use of the pension scheme. But the expectancy measure – which can be regarded as a far-sighted feature – is also influenced by the behavior of the studied population in the preceding years. Another advantage is that expectancy shows whether or not the development tends toward the targets set in the official employment and pension policies.

For an individual at a particular age, *working-life expectancy* is the expected number of working years remaining in one's life (Nurminen 2008).[1] While this is a hypothetical construct that cannot be directly measured, it is an intuitive and broadly accessible concept. As such it can provide the means for summarizing and comparing the labor market status of surveyed populations as well as for monitoring the time trends in employment statistics. Summary measures for the working years can provide useful indicators for evaluating labor force potential plus for evaluating the need for policy adjustments. Although the calculation of

1 This definition is interpreted statistically as the expected (average) value of the distribution of the length of working-life in the population, which is consistently estimated by the sample mean. It is the future duration or occupation time in the employed state conditional on an individual's initial age. Note that 'future' time is ingrained in the concept of expectation. However, in the context of a birth cohort's follow-up, it refers to the aging of its members within the range of a calendar year period that was used as the population-time data base for the estimation of the multistate regression model. Therefore, the working-life expectancy should not be interpreted as a predicted value. Forecasting beyond the observed data base is treacherous, *e.g.*, because the premises of the underlying regression model may change. For an elaboration of this issue, see Appendix E.

the working-life expectancy tables is complicated, their wide use demonstrates that they nevertheless are relevant and comprehensible.

Approaches to measure the length of working life vary according to what object exactly is being targeted and how it is formally estimated. Because of the abundant early retirement in the past, discussion on extending working lives has focused largely on pension systems (Kannisto *et al*. 2003; Kannisto 2012). Increasing life expectancy also suggests that a natural way to extend working lives is to push the final exit from working life further in the life course. However, over the past several years there has been a growing understanding in Finland and in other parts of Europe that it is useful to see the question of extending working lives in a context of the entire life span (Hytti and Nio 2004; Vogler-Ludwig 2009; Hytti and Valaste 2009). The duration of working life is influenced not only by retirement but also by other age-related activities over the course of life, such as participation in education and child care, spells of unemployment or sickness absence.

Measures of the participation in working life over the life span may be founded on the experiences of actual cohorts. The time that cohort members have spent in working life may be measured retrospectively, taking persons alive at the end of the working-age years and calculating the time they have participated in working life over the course of their life (*e.g*. Lehto 2012; Salonen 2012; Tuominen *et al*. 2010). Alternatively, an actual cohort may be followed prospectively from birth up to over the working-age years, taking into account the mortality of the cohort. Both methods estimate the length of working life of a cohort as it has realized in past circumstances over the history of the cohort. They do not, however, provide us with information on how the length of working life is evolving in time and under prevailing circumstances.

Expectancies aim to capture the present state of a population. They estimate the average time spent alive in a defined state (alive, employed, not retired, *etc.*) computed from age-specific probabilities or risks over a period of time. *Partial life expectancies*[2] up to a given age were first used in health metrics to calculate the 'healthy life expectancy' of the total life expectancy as a response to the intriguing qualitative question of whether the increase in life expectancy adds to 'healthy' or 'un-healthy' years. Or, to put the question quantitatively: What

2 The term 'partial life expectancy' refers to the average number of years remaining between specific ages x and z (where $15 \leq x < z < 65$, the limiting age) by persons alive at an exact age x. In the context of this analysis, therefore, the *sum* of the working-life expectancy and the expectations of time spent in the states 'unemployed' and 'economically inactive' is equal to the partial life expectancy between exact ages 15 and 65 years, as normally defined by demographers.

share of the increase in life expectancy is lived in a state of disability? For a demographic-epidemiologic application, see Davis *et al.* (2002b).

Working-life applications of partial life expectancy have gained growing interest over the past few decades as an analogous issue of how participation to worklife develops in relation to total life expectancy (Hytti 1998; Nurminen and Nurminen 2005; Hytti 2009). As a summary statistic of age-specific participation to working life, working-life expectancy measures the average length of working life remaining for an individual at a given point in time. It is usually gauged in units of expected years remaining in working-life that are meaningful to ordinary laypersons. Summary measures of the working-life years can provide useful indicators for evaluating labor force potential.

A study for the EU Commission sought to investigate the working-life indicator which should complement the monitoring instruments of the European Strategy by focusing on the entire life cycle of active persons and persons in employment (Vogler-Ludwig 2009). The study recommended using the working-life expectancy as one of the core labor market indicators at European and national level. Recently the Employment Committee decided that the working-life expectancy will replace the average age of withdrawal from labor force (or exit age) indicator. The expectancy indicator will be utilized for monitoring the European employment guidelines. The measure has already been included in the Joint Assessment Framework indicator package by experts who peruse the trends and targets in employment set for the EU's growth strategy.

Working life expectancies have been applied using various definitions of working-life participation. In one of the early studies in the field, Hytti (1998) measured active life time as opposed to the time spent in retirement. Several studies have defined *participation to working life* as equal to *labor force participation* (*e.g.* Hytti and Nio 2004; Hytti and Valaste 2009 [*labor market expectancy*]; Vogler-Ludwig 2009 [*duration of active working life*]). The problem with this definition is that time spent gainfully employed and time spent unemployed are pooled together. By pooling the employed and unemployed individuals these expectancies obscure the age-pattern of working-life participation because employment and unemployment are highly age-specific phenomena but in a mutually reversed manner. Thus, some studies have defined the expectancy of labor market time as the *expectancy of time spent employed* (Hytti and Valaste 2009; Vogler-Ludwig 2009). Yet another way to measure the participation in working life is in terms of *working time*. This has been carried out by calculating the expected lifetime duration of working time in hours (Vogler-Ludwig 2009) or by dividing employment time to full-time and part-time employment (Hytti and Valaste 2009), which would also include those working only part of the year due to the seasonal nature of their job. Thus, depending on one's education, level of skill, and type of job, a non-trivial fraction of one's working life might be spent not working.

We prefer to define the working-life expectancy exclusively in terms of *participation in gainful employment*. However, to get an even clearer picture, we complement working-life expectancy with expectancies estimated for time spent in unemployment and for inactive time. By explicitly distinguishing the multiple relevant labor market states and estimating their expectancies we aim to gain a better understanding of the interplay between the working and non-working life over the entire life span. While we recognize the significance of working time and, in particular, the role of part-time work in labor market policies aimed at lengthening life-time employment and adding flexibility to different phases of life, measuring working-time expectancy is beyond the scope of the present study.

Working-life expectancy may be estimated using either *marginal probabilities* (prevalence rates) or *transition probabilities* (incidence rates) (*e.g.* Davis *et al*. 2007). Prevalence-based working-life expectancy describes the prevailing worklife-participation rate in a cross-sectional sample of a population (Davis *et al*. 2001). This rate incorporates workers' past labor market experiences as these manifest in the age-specific frequencies of being occupied in a labor market state during a short time period. Incidence-based expectancy is calculated from longitudinal cohort data that are required to estimate transitions between various states (Davis *et al*. 2002a). While ordinary current life table technique is set up on a calculation of employment probabilities based on a *period life table* (Sullivan 1971), we base our analysis on a *cohort life table* modeling approach (Davis *et al.* 2001).[3] A limitation of the former type indicators appears to be that they are descriptions of the whole life cycle rather than specific phases of working life (like combined periods of unemployment). Moreover, they describe the current state of working life participation over all ages, rather than providing

3 Life cycle tables are used for calculating working-life expectancies. There are two types of life tables: period (or current) life tables and cohort (or generation) life tables.

The period life table is based on observations over a special period of time (*e.g.* one year or an average over a period) and assumes the prevalence of observed survival rates for the remaining lifetime of all ages. The period life table can be seen as a snapshot of current mortality. It does not represent the expected mortality rates of an actual birth cohort as far as mortality rates will change in future.

The cohort life table follows a specific birth cohort (*e.g.* all persons born in 1945) from their birth through each age until all of them die. For the construction of a cohort life table data over long periods are needed. As life expectancy of the present population is the main issue of interest, the calculation of cohort life tables requires forecasting mortality rates.

estimates for the years spanning the entire working life. Yet the limitations pertain only to the traditional current life table technique, not to the multistate cohort life table approach.

Considering the advantages and limitations of the two comparative methods, our stand is that, while the period life table expectancy is the most common measure in a readily useable form, the regression-based cohort life table expectancy is more appropriate and superior for demanding statistical research objectives. Cohort life table expectancy can be theoretically founded on large-sample, weighted least squares theory, and therefore allows reliable data analyses and stochastic inferences (*inter alia*, with respect to significance tests, interval estimates, interaction effects, time trends, and projections). For further discussion of the comparative properties of the two approaches, see Section 9.2.

Working-life expectancies are formally defined in terms of working-life table probabilities, thus they have a direct probabilistic interpretation. The working-life expectancy measure may be expanded to *multistate* working-life expectancies by building it on the probability of occupancy in a given state amongst the multiple states of work ability or labor market activity (Nurminen and Nurminen 2005). Davis' multistate life table method has the distinct property that it allows the summary to be *multivariate*. In other words, the parameter of the outcome state (*i.e.* the logarithm of the ratio of the probability of a given state to the probability of the referent state) is expressed in terms of multiple covariates of a temporal, spatial and socioeconomic nature. Given available data, the covariates may also represent alternative labor market or pension policies. An analysis of working-life expectancy using a multistate and multivariate regression model enables one to capture the joint impact of several simultaneously contributing causes of early retirement (*e.g.* work disability). We utilize these attributes of the method in order to gain an accurate picture of the multidimensional changes in Finnish working-life expectancies during the years 2000–2010.

3 The labour force survey data

By nature, the evolution of labor force over time is a dynamic process in which accession to and separation from the working population occur during an individual's working life multiple times and often via different paths. In this section, we consider the population experience formed by the entire Finnish labor force across the years 2000–2010.

We used the Finnish Labour Force Survey (*LFS*) data (Official Statistics of Finland, OSF 2011a) to apply the multistate life table method and to estimate the expectancies for the time spent in the contrasted contingencies of employed, unemployed and economically inactive in a given age and population sub-group. The labor market states are considered mutually exclusive (non-overlapping). The states were classified according to the definitions used in the *LFS* (Quality Description: Labour Force Survey, Official Statistics of Finland, OSF 2011b).

- A person is *employed* if (s)he has during the survey week been in gainful employment for at least one hour against pay in money or fringe benefits, or to make a profit, or has been temporarily absent from work.
- A person is *unemployed* if he or she is without work during the survey week, has actively sought employment in the past four weeks as an employee or self-employed and would be available for work within two weeks.
- The active *population* (*labor force)* comprises all persons who are employed or unemployed during the survey week.
- The *economically inactive population* consists of persons who are neither classified as employed nor as unemployed. It can also be referred to as persons outside the labor force. These include students, conscripts and persons on disability or old age pension.

There are a variety of register-based administrative data available to exploit for the estimation of statistics on employment and unemployment in the *LFS* (Djerf 1977). The benefits of also utilizing auxiliary data are in efficiency improvement and reduction of bias (Lehtonen and Veijanen 1999). However, the register-based jobseeker status obtained from the records of the Ministry of Labour is defined differently from the employment status measured in the *LFS*. Yet the survey variate on unemployment is based on a standard ILO definition, which correlates auspiciously ($r = 0.8$) with the register-based jobseeker status.

In the Finnish labor markets the number of those who are unemployed is marginal at age 65 and practically nonexistent above the age of 70. Since the introduction of flexible pensionable age in 2005, with the lowest age limit at 63 years of age, the number of unemployed at that age dropped in practice close to zero.

The Finnish Labour Force Survey is an on-going survey that collects statistical data on the participation in employment, unemployment and other activity of persons outside the labor force, among the population aged between 15 and 74. The *LFS* controls respondents burden using rotation group data that consist of observations on individuals comprised of a stratified random sample drawn twice a year from the population database. The survey is a panel study, in which the same person is interviewed five times at three months intervals. The monthly sample consists of some 12,000 persons and data that are obtained by means of computer-assisted telephone interviews. The information given by the respondents is used to produce a representative picture of the activities of the entire working-age population.

The multistate life table method can be applied to estimate the marginal probabilities of a given number of states at subsequent ages. We employed a basic model of four states: employed, unemployed, economically inactive and deceased. The restriction of the number of states to four was dictated by two reasons: data unavailability and model over-parametrization.

In principle those who are outside the workforce can be divided into five groups: students, conscripts, persons taking care of children or other family members, disability or old-age pensioners, and other persons or persons with undefined status. However, this information is only readily available from the year 2008 onwards. The division of persons outside the workforce into two practicable groups by one-year age categories would have been difficult since the numbers of students and conscripts in the older age groups are close to nil. On the other hand, there are extremely few persons on disability or old-age pension in the younger age groups. Before year 2008, one could classify those outside the labor force merely to conscripts and other outsiders. But this would not be sensible because the share of conscripts of all inactive people is only one percent.

In deciding the number of parameters necessary for a relevant and satisfactory specification of a model one has to balance between reasonable parameterization and computational feasibility. The multistate logistic model is parameterized separately for each state. It follows that if, for example, a model with four states (or three log ratios) includes 3 times 10 or 30 parameters, an addition of another state will increase the total number of parameters to approximately 40. In practice this over-parameterization often means severe computational problems and the model estimation equations may not be solved.

The numbers of annual fatalities in the study years were extracted from the population files kept by Statistics Finland. The statistics on deaths cover persons permanently domiciled in Finland. ‘Deceased’ was taken as a reference state in the four-state design. In the analyses we used aggregated data displaying estimates of population frequencies of the three-to-four states by gender, and single-year working-age groups, taken from 15 to 64 years, for the years 2000–2010. In all, the dataset consisted of a 4-dimensional array of 4,400 frequencies (Table B.1).

The aggregate frequency data were further subdivided for separate analysis by level of education. In the Finnish *LFS* the information on the highest achieved level of education for each interviewed person was obtained from the Register of Completed Education and Degrees. The level of education is classified according to the International Standard Classification of Education (ISCED) (UNESCO 1997). For our analyses, we merged the levels of education into three groups as follows: the level ‘tertiary’ includes all tertiary level degrees (ISCED levels 5–6); the level ‘secondary’ includes upper-secondary degrees (ISCED levels 3–4); the level ‘primary’ refers to those without a degree and with only primary or lower secondary education (ISCED levels 1–2). When studying educational differences we used a three-state model including only the three labor market states, since data on deaths were not available in the sub-populations by educational attainment.

Due to the sampling scheme, in certain cells of the cross-classified data there were no interviewed persons. To avoid these ‘non available’ observations which would inhibit the statistical analysis (if extended beyond the range 25–64 years), the missing frequencies were imputed by an arbitrary small number, 1, 5 or 20 (the smallest possible estimated frequency in a cell is approximately 20).

The reliability of the figures of the *LFS* is affected by non-response, measurement errors and random variation due to sampling (see OSF 2011b). The non-response rate was 20 percent on average. Non-response was ignored in the estimation as it is believed to make little difference. Survey non-response is corrected in the *LFS* by applying survey weights. Development and testing of the questions, interviewer instructions and the user interface, and training of interviewers are measures that have been used by Statistics Finland to contain measurement errors.

When evaluating roughly the magnitude of random variation due to sampling in different situations, the main principle is that the larger the population described by the figures is, and the larger the sample from which the figures are calculated is, the less uncertainty due to sampling there will be in the figures. Annual figures, which are averages over the whole year, are the most accurate and were used in this study. Regarding the numerical magnitude of sampling error, if for example the annual estimate of the employed in the subgroup is 10,000 persons, the relative standard error of the estimate is only 4.0 per cent, whereas for the estimate of 10,000 unemployed, the relative standard error is twice as large, 8.0 percent.

The study base is construed as being formed of cross-sectional samples of a dynamic population (residents of Finland in a survey week). The surveys sample the same population in successive cycles but with no attempt to track particular individuals from one cycle to the next. Because the samples are superimposed, this scheme creates autocorrelation between the observations at successive survey weeks. This fact has to be accounted for in the standard errors of probability estimates.

4 Multistate cohort life table method

The approach to the analysis of cohort life table data under a multistate model proceeds in three phases: estimation of 1) the regression model parameters, 2) the state occupation probabilities, and 3) the components of the partial life expectancies. A brief outline of the elements used in the analysis is presented in this section and in more detail in Appendix A. Subsequent Sections 5, 6 and 7 present the empirical estimates.

The large-sample cohort life table methodology (Davis *et al*. 2001) has been previously applied to the Finnish workforce (Nurminen *et al*. 2005). It enables inference for stochastic processes using aggregated survey data. A multistate discrete-time model is built to estimate the probabilities governing annual movements of the working-age population between the employment state and other related states. The objective is to estimate cohort occupation times in these states. The approach obtains cross-sectional information from sequential independent surveys in an attempt to reconstruct relevant parts of the underlying longitudinal process that generated the data for the years 2000–2010.

It is suitable to conceptualize the method in terms of a hypothetical *cohort*[4] of a number of lives initially aged 15 years. Of importance are the marginal probabilities that an individual is in state j at the initial age and at a subsequent age x, written $p_j(x)$. In the present application, $j = 0$ denotes ‘alive’ and $j = 1,2,3,4$ indexes the exhaustive (non-overlapping) partition into four states (1) ‘employed’, (2) ‘unemployed’, (3) ‘economically inactive’, and (4) ‘dead’. Here our interest is on estimating the marginal probabilities and working-life expectancies that are not conditional on the initial state, but only on the initial age. Aggregated data were available at ages $x = 15, \ldots, 64$ years.

Estimation of the unconditional probabilities $p_j(x)$ is done by a large-sample version of logistic regression. We shall call $p_1(x)$ the *working life survival curve.* Advantage is taken of the fact that official statistics almost always comprise large datasets, which in the present case translates to large n, the number of individuals in the age cohort. The main theoretical results of the method are given in Davis *et al*. (2001) and explicated in the thesis by Davis (2003).

4 A cohort is a closed population in the meaning of being closed for exit (Miettinen 2011). In this context, ’cohort’ is taken to mean a sample from a population born in the same year (birth cohort). Owing to the sampling scheme it has turnover in membership in a given period of time. Nevertheless, the concept is employed in the large-sample estimation of expectancies.

With state 4 (dead) as the reference, we formed the log partial odds, that is, the ratio of the probability of being in state *j* at a given age *x* relative to state 4:

$$\xi_j(x) = \log\{p_j(x)/p_4(x)\}, j = 1,2,3. \quad \text{(Eq 1)}$$

There is a one-to-one correspondence between log partial odds with respect to the referent state and all the marginal probabilities for all the states, so that we can estimate the $p_j(x)$ through the use of regression estimates for the $\xi_j(x)$.

In the three-state model, the state of 'economically inactive' was taken as the reference state. Deaths could be regarded as being absorbed in the third ('other') state or ignored, because of the low mortality rates (in 2010): 1‰ at 37 y, 3‰ at 50 y and 1 percent at 63 y. The rates are of the same order of magnitude as the relative standard error estimates of the sub-population sizes (see below).

Exploratory analysis can be used to suggest a parametric form for the partial log ratios, $\xi(x) \equiv \xi(x;\beta) = Z(x)'\beta$, with $Z(x)$ an appropriately chosen design matrix of the explanatory variates (x = age, *etc*.), and the estimation of the parameter vector β is done by weighted least squares. With the resulting estimate $\hat{\beta}$ we have the derived parameter estimates:

$$\begin{aligned}
&\hat{\xi}(x) = \xi(x;\hat{\beta}),\\
&\hat{p}_j(x) = \hat{p}_4(x)\exp[\hat{x}_j(x)], \text{ j} = 1,2,3, \quad \text{(Eq 2)}\\
&\hat{p}_4(x) = \{1+\Sigma_{j=1}^{3}\exp[\hat{\xi}(x)]\}^{-1}
\end{aligned}$$

Thence the estimated working-life and related expectancies of interest, e_j(z), for the three states *j* and a particular age *z*, $15 \leq x < z \leq 64$, are defined as a definite integral function

$$\hat{e}_j(z) = \int_z^{64} \hat{p}_j(x/z)dx. \quad \text{(Eq 3)}$$

The expectation of main interest, e_1, yields the *working-life expectancy* (Nurminen 2008). These quantities are conditional only on the fact that an individual is alive at exact age 15, and they should be distinguished from health working-life expectancies conditional on knowledge of the initial worklife or state. The expectation $e_0 = \Sigma_{j=1}^{3} e_j$ is the partial *life expectancy* between the exact ages *z* and 65 for a person known to have been alive at age 15, and $\Sigma_{j=1}^{4} e_j = 50$.

In Equation 3, the estimates for working-life expectancies from age 15 (say) were really for persons who enter the workforce (or first comes under observation) on their 15th birthday and retire on their 65th birthday. Thus the working-life expectancies sum to the duration of maximum remaining work life at age 15, that is 50 years. The genealogy of these data is that they come from rotating cross-sectional samples from a dynamic population with changeover of membership. The design implies that a 15-year-old person in the *LFS* could have been interviewed at any point in time between his 15th birthday and the day before his 16th birthday. Therefore, the working-life expectancies add to 49.5 (= 65 – 15 – ½) years; ½ is subtracted since persons enter work on average in the middle of the age interval (15, 16). This entails that at age $x = 15$ the expected future occupation time in state j is computed as

$$\hat{e}_j(x) = \hat{p}_j(x)/2 + \int_{z+1}^{64} \hat{p}_j(x/z)dx, \qquad \text{(Eq 3')}$$

where $\hat{p}_j(x)$ is the estimated prevalence of state j at initial age x. Numerically, the difference to Equation 3 is decimal. Although this assumption introduces ostensible pedantry, we have maintained the multiplier of ½ because this will make the present estimates methodologically consistent with those of the preceding Working Paper (Nurminen 2011) and with the theory of stochastic processes for life tables (*cf*. Chiang 1968, Section 10.5).

The large-sample arguments apply to estimating cohort survival curves and expectancies as functions of age for a given year. However, we had data available for the years 2000 to 2010 and clearly variation with year is also of interest. It is therefore natural to model the vector of log ratios as a function of both year t and age x by $\xi(t,x;\beta) = Z(t,x)'\beta$, where Z is an appropriately chosen design matrix and β is the regression parameter vector to be estimated (Section 5). Bearing in mind that only cross-sectional data are available, our main objective in the quantification of the working-life expectancies with a special outlook to longitudinal trends over time and to comparisons between sub-domains of the population.

5 Estimates of regression model parameters

As was remarked in the previous section, the estimation of expectancies is done by integration of the probabilities, p_j, based on a multivariate regression model, $\xi(t,x;\beta) = Z(t,x)'\beta$. In this section, we explain the specific steps of the modeling in order to make the estimation obvious. Some guidelines are offered to aid in the interpretation of the modeling results.

While regression modeling in this study primarily serves descriptive purposes, it nevertheless permits making statistical inferences. For example, we tested the significance of a gender difference between occupancies in labor market states. The finding of a significant change in the working-life lengths before and after the pension reform should not be given a direct causal explanation. This is because the reform involved several incentive measures directed to the promotion of longer careers whose implementation in practice varied with time.

Two main factors were present in all the models, *viz*. age and calendar year. Additional variates were included in the four-state models that were applied separately for men (Table 5.1) and women (Table 5.2). Basically the same variates were entered in the three-state models that were applied in the analysis of the population sub-groups by level of education. The rationale for the selection of the terms into the models is given next.

A variety of plausible alternative statistical models can be constructed to describe the data. After considerable deliberation we decided on appropriate models for male and female data. Our formulation of the proposed multistate model for four working-life states started with the estimation of sets of multiple explanatory covariates for the genders. The selection of the estimated regression model parameters (*b*) was tentatively based on significance testing using the standard errors (*se*) calculated using the method of Liang and Zeger (1986). This choice yielded several significant variates for males and females preliminarily assessed by a criterion based on standard-Gaussian (normal) test statistic: $z = b/se > 1.64$, corresponding to the 95th centile of the distribution (one-tailed probability).

However, the selection of the independent variates (regressors) based purely on significance test results is commonly unstable due to correlation between some of the covariates. Moreover, in case of a significant higher order polynomial term, the main effect term and the lower order terms should also be included in the model. Nevertheless, the working-life expectancies estimated under somewhat different model forms do not differ much from each other in magnitude. In deciding on a suitable model, observed prevalence rates versus fitted probabilities of the states were examined. Polynomial function (up to a cubic term) at age *x* and its product terms with calendar year *t* for the log-ratios were estimated. In the modeling the variates year and age were centered with respective means 2005 and 40. To model the particular behavior of the estimates at teen- and senior-ages, we included indicators for the teen and senior age groups 15–19 and 60–64 years.

Annual change in the volume of the gross domestic product (*GDP*) from the previous year was included as an explanatory variable in the regression model. *GDP* reflects the recession effects and episodes of unemployment over the years. Economic conjunctures usually affect the younger (under 30-year-old) persons' employment faster and stronger than they do other age groups. These situations occurred in around year 2003 and in 2009 (*cf.* Figure 7.1.5). Because significance testing confirmed this occurrence, we entered for males a term for *GDP* modified by the age-specific prevalence of unemployment.[5] While the term was statistically highly significant for modeling men's unemployment probability, it was not significant for women and was excluded from the female model.

A further indicator was entered in the model for the years starting from 2005 when the pension reform law was enacted in Finland. This indicator captured overall changes in the level of employment from the period 2000–2004 to 2006–2010; there may have been many other changes besides the pension reform. The effect was significant for the states of 'unemployed' and 'economically inactive' for men (Table 5.1) but non-significant for women (Table 5.2).

The binary pension reform year indicator correlated only to the general decline of unemployment. Thus, we added a more specific indicator for unemployment pension that acknowledged the lower age limits and starting years of eligibility for the 'unemployment tunnel'.[6] This latter term was significant for all three states and both genders.

The 'final' fitted regression models with 30 parameters for male (Table 5.1) and 25 for female (Table 5.2) log ratios were used to estimate the working-life expectancies. These models are in three respects different to the previous ones

5 To adequately describe the distributional form of male unemployment rate in the age-year-axis (Figure 6.1.c), the marginal mean values of the rates were calculated in 5-year age groups over the eleven calendar years. These means were multiplied by the annual *GDP*s to obtain product terms, which were used in the modeling.

6 Unemployment pensions may be awarded to long-term unemployed in both national and earnings-related pension schemes. Elderly unemployed are eligible for earnings-related unemployment benefit until retirement age and old-age pension. The so-called 'unemployment tunnel' had the lower age limit of 55 years until 2005, and now it is 57 years.

given in the Working Paper (Nurminen 2011): *viz.* 1) the data now contain for the year 2010 observed values instead of predicted values, 2) the teen-age indicator covers the age range ≤ 19 y in lieu of ≤ 17 y, and most importantly, 3) the standard errors of the variates were estimated by the more accurate, 'generalized' estimating equations, extended version of the Liang-Zeger method (Appendix B), rather than by 'independence' estimating equations. The latter estimators arise under the working assumption that repeated observations from a subject are independent of one another. In the *LFS* data with superimposed samples, the repeated observations on a panel of individuals cannot be considered independent even when the sample sizes are large. Thus ignoring autocorrelation when it exists will lead to invalid (too small) standard errors for the regression coefficient estimates, and an inaccurate estimate of their correlation structure.

In investigating the effect of education, the adopted strategy was to perform separate analyses of data ranked by the attained level of education. The aim was to quantify the impact of education on the working-life expectancy estimates with emphasis on comparative analysis between sub-domains of data. The three-state model for males comprised a reduced number of 20(18) parameters and 18(16) for females for an age range of 15(25) to 64 years.

In a regression model with multiple dependant states (regressands) and multiple independent (regressor) variates, the interpretation of the magnitude of the parameters is not a simple issue. It is difficult to disentangle the interdependent involvements of the main terms and their product terms, because of the coding of the statistical variates. One can merely deduce the direction of the effect from the sign of a particular coefficient that it is directed either above or below the general mean (*i.e.* the intercept term). The use of the statistical terms 'effect' and 'interaction' do not carry any implication of causality. There is a subtle balance between description and analysis. A prerequisite task of modeling is to reproduce the pertinent features of the observed data. This serves as a basis for formulating the way in which the state probabilities depend on a joint function of the variates being considered.

The appropriateness of the model was assessed by how well it expresses the probabilities of the state realizations. This was approached by considering the outcomes separately and by comparing the observed prevalence rates with the respective model-fitted probabilities, estimated by computing the compound score yielded by the regression function. Figures 6.1 and 6.2 provide 3D graphs for visual inspection of the success of the fit.

Table 5.1

Estimates of regression model parameter coefficients and standard errors of the three working-life states for males.

Regression term	Estimates for state employed			Estimates for state unemployed			Estimates for state inactive		
	Para-meter*	Coefficient§	Standard error	Para-meter	Coefficient	Standard error	Para-meter	Coefficient	Standard error
Intercept (mean)	$\boldsymbol{\beta_{1}}$	6.04e+0	1.86e-2	$\boldsymbol{\beta_{9}}$	3.38e+0	2.31e-2	$\boldsymbol{\beta_{21}}$	3.34e+0	3.53e-2
Age (centered at 40 years), x	$\boldsymbol{\beta_{2}}$	-6.66e-2	1.26e-3	$\boldsymbol{\beta_{10}}$	-6.37e-2	2.43e-3	$\boldsymbol{\beta_{22}}$	-4.42e-2	4.44e-3
Squared term, x^2	$\boldsymbol{\beta_{3}}$	-2.66e-3	1.07e-4	$\boldsymbol{\beta_{11}}$	-2.77e-4	1.05e-4	$\boldsymbol{\beta_{23}}$	3.84e-3	1.53e-4
Cubic term, x^3				$\boldsymbol{\beta_{12}}$	-8.78e-5	1.10e-5	$\boldsymbol{\beta_{24}}$	-7.69e-5	1.67e-5
Teen age indicator, $I(15 \leq x \leq 19)$	$\boldsymbol{\beta_{4}}$	-4.49e-1	8.03e-2	$\boldsymbol{\beta_{13}}$	-4.99e-1	7.13e-2			
Senior age indicator, $I(x \geq 60)$	$\boldsymbol{\beta_{5}}$	-1.59e-1	3.53e-2	$\boldsymbol{\beta_{14}}$	-6.80e-1	1.27e-1	$\boldsymbol{\beta_{25}}$	3.03e-1	8.48e-2
Calendar year (centered at 2005), t	$\boldsymbol{\beta_{6}}$	3.35e-2	2.64e-3	$\boldsymbol{\beta_{15}}$	4.30e-2	5.49e-3	$\boldsymbol{\beta_{26}}$	4.39e-2	7.63e-3
Product term, tx				β_{16}	-4.48e-4	3.06e-4	$\boldsymbol{\beta_{27}}$	-1.65e-3	2.35e-4
Squared term, tx^2				β_{17}	3.83e-5	2.42e-5	$\boldsymbol{\beta_{28}}$	-5.70e-5	2.13e-5
Pension reform year indicator $I(2005 \leq t \leq 2010)$				$\boldsymbol{\beta_{18}}$	-2.62e-1	3.28e-2	$\boldsymbol{\beta_{29}}$	-8.09e-2	3.76e-2
Unemployment pension 'tunnel' indicator	$\boldsymbol{\beta_{7}}$	1.83e-1	3.36e-2	$\boldsymbol{\beta_{19}}$	3.79e-1	4.73e-2	$\boldsymbol{\beta_{30}}$	1.56e-1	7.50e-2
Annual change in gross domestic product (GDP)	β_{8}	2.16e-3	2.06e-3						
GDP modified by age-specific unemployment prevalence rate				$\boldsymbol{\beta_{20}}$	-9.94e-3	2.74e-3			

* Statistically significant regressors are marked in boldface figures. Terms selected into the model have consecutive sub-indices.

§ Exponential notation, *e.g.*, 6.04e+0 = 6.04 x 10^{+0} = 6.04.

Table 5.2

Estimates of regression model parameter coefficients and standard errors of the three working-life states for females.

Regression term	Estimates for state employed			Estimates for state unemployed			Estimates for state inactive		
	Para-meter*	Coefficient§	Standard error	Para-meter	Coefficient	Standard error	Para-meter	Coefficient	Standard error
Intercept (mean)	**β_{1}**	6.84e+0	2.70e-2	**β_{10}**	4.16e+0	2.75e-2	**β_{19}**	4.83e+0	4.33e-2
Age (centered at 40 years), x	**β_{2}**	-7.28e-2	1.47e-3	**β_{11}**	-9.58e-2	1.42e-3	**β_{20}**	-1.12e-1	6.60e-3
Squared term, x^2	**β_{3}**	-1.94e-3	1.33e-04	**β_{12}**	-4.43e-4	1.42e-4	**β_{21}**	2.04e-3	1.78e-4
Cubic term, x^3							**β_{22}**	6.71e-5	2.39e-5
Teen age indicator, $I(15 \leq x \leq 19)$	**β_{4}**	-7.68e-1	1.38e-1	**β_{13}**	-3.05e-1	1.15e-1			
Senior age indicator, $I(x \geq 60)$	**β_{5}**	-4.55e-1	4.16e-2	**β_{14}**	-1.12e+0	8.83e-2	**β_{23}**	2.81e-1	1.16e-1
Calendar year (centered at 2005), t	β_{6}	-7.47e-3	7.98e-3	**β_{15}**	-4.99e-2	9.00e-3	**β_{24}**	-1.02e-2	5.51e-3
Product term, tx	**β_{7}**	1.52e-3	4.01e-4	**β_{16}**	1.25e-3	4.69e-4			
Squared term, tx^2	**β_{8}**	1.06e-4	3.44e-5	**β_{17}**	1.08e-4	3.94e-5			
Unemployment pension 'tunnel' indicator	**β_{9}**	1.47e-1	4.91e-2	**β_{18}**	3.29e-1	5.93e-2	**β_{25}**	3.37e-1	7.74e-2

* Statistically significant regressors are marked in boldface figures. Terms selected into the model have consecutive sub-indices.

§ Exponential notation, *e.g.*, 6.84e+0 = $6.84 \times 10^{+0}$ = 6.84.

6 Estimates of labour market state probabilities

In this section we present the model-based estimates of the state parameters. Figures 6.1 (males) and 6.2 (females) show the observed population rates (left panel) and the estimated probability surfaces (right panel), smoothed by *spline function*.[7] The estimated probabilities were derived from the four-state-model including the mutually exclusive states 1) 'employed', 2) 'unemployed', 3) 'economically inactive', and 4) 'deceased'. Numerical values for the estimated probabilities of the occupancy states including the reference state 'deceased' are given in Appendix Table C.1 for males (model with 30 parameters) and Table C.2 for females (model with 25 parameters).

The left hand sides of Figure 6.1 (males) and Figure 6.2 (females) show the rather rugged sample-based prevalence rates (especially in case of the unemployed) which were used to estimate the probabilities and thereby expectancies.

Comparison of the left hand side and right hand side figures reveals that the estimated probabilities reflect quite well the significant features of the prevalence data. The estimated probabilities of being employed increased rather consistently throughout the decade 2000–2010 in all age groups and for both genders. During the economic downturn in 2001–2003, the estimated probabilities of unemployment grew for men, but diminished thereafter during 2004–2008. The change was significant for males, but for females the decline was small. The unemployment rate was above average among young people aged 15 to 24 years in 2000–2010, with the highest rates reaching 17 percent for 20-year-old males in 2009 and 15 percent for 15-year-old females in 2003. The model for the unemployment probabilities displays the significantly elevated risk pattern for young males. Although the unemployment rates were pronounced for 15-year-old females in the years 2005–2010 (Figure 6.2c), these observations were too few to show a significant rise in Figure 6.2d.

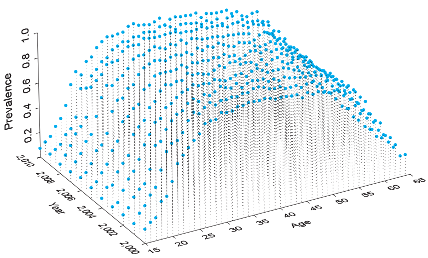
7 Smoothing splines are local cubic functions that minimize a penalized residual sum of squares, drawing a smoothed regression curve through the data points. The degree of smoothness may be selected automatically using cross-validation or may be specified in terms of degrees of freedom. (Venables and Ripley 2002.)

Figure 6.1

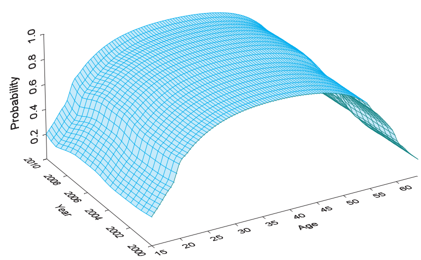
Observed population prevalence rates (per 1,000 people) and fitted probability surfaces smoothed using cubic spline interpolation, for three states 1 = 'employed', 2 = 'unemployed', 3 = 'economically inactive', for males aged 15–64 years in Finland 2000–2010:

(a) observed, employed *(b) fitted, employed*
(c) observed, unemployed *(d) fitted, unemployed*
(e) observed, inactive *(f) fitted, inactive*

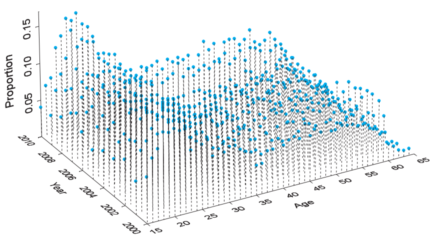
a) Population employment rates for males



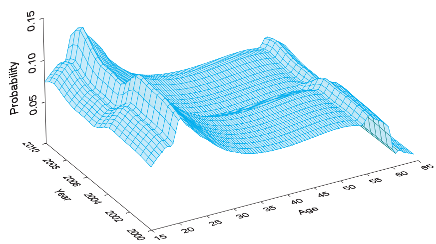
b) Probability surface for employed males



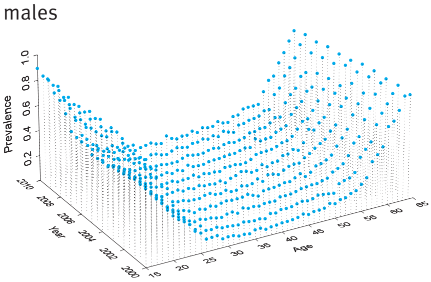
c) Population rates for unemployed males



d) Probability surface for unemployed males



e) Population rates for economically inactive males



f) Probability surface for economically inactive males

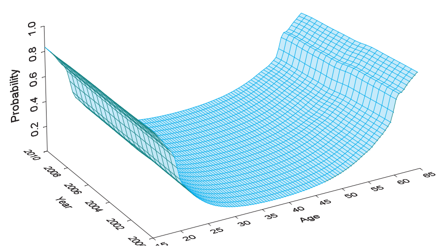
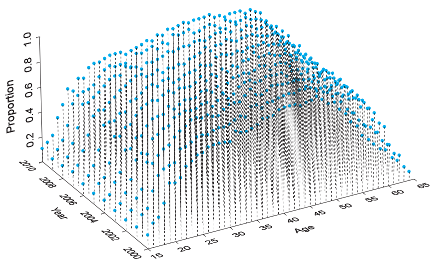


Figure 6.2

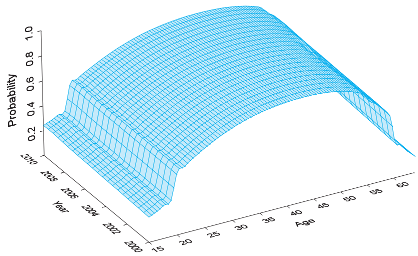
Observed population prevalence rates (per 1,000 people) and fitted probability surfaces smoothed using cubic spline interpolation, for three states 1 = ‘employed’, 2 = ‘unemployed’, 3 = ‘economically inactive’, for females aged 15–64 years in Finland 2000–2010:

(a) observed, employed	*(b) fitted, employed*
(c) observed, unemployed	*(d) fitted, unemployed*
(e) observed, inactive	*(f) fitted, inactive*

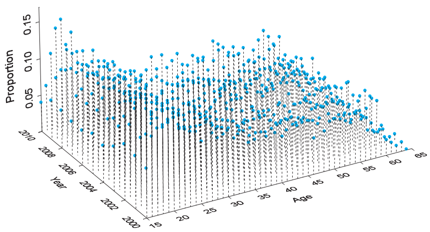
a) Population rates for employed females



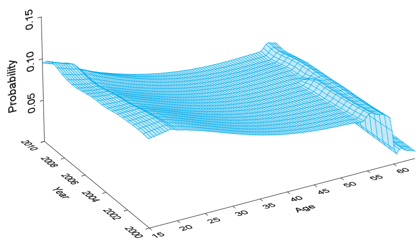
b) Probability surface for employed females



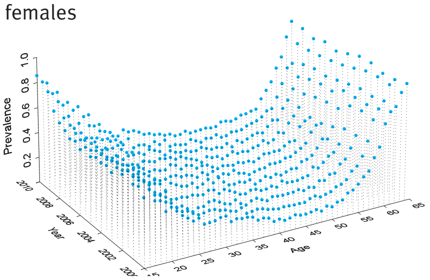
c) Population rates for unemployed females



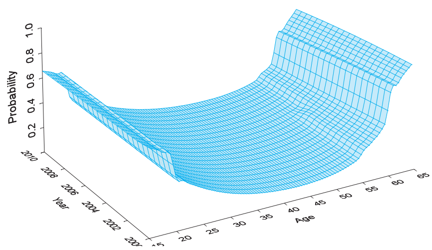
d) Probability surface for unemployed females



e) Population rates for economically inactive females



f) Probability surface for economically inactive females



Next we shall carry out preliminary analyses by examining age-specific changes in the estimated employment probabilities for single-year age groups. Further, we shall compare the age-specific changes in employment probabilities with the corresponding changes in the probabilities of unemployment and inactive time.

Although the improvement in women's employment probabilities was modest at younger ages, Figure 3 suggests that there may be a gender difference in the age-specific development of the participation to working life: among women the time spent in employment increased at every age, among men only in the oldest age groups.

Figure 6.4 displays the change in the probability of employment between the years 2000 and 2010 from age 15 to 64 years. For women the probabilities increased throughout the working-age years, thereby extending the length of their working careers.

A more equal distribution across the age of the increase in employment time among women is related with gender differences in unemployment during the study period. Figure 6.5 depicts that, from year 2000 to 2010, the age-specific unemployment probabilities decreased at almost every age among women. Among men, on the other hand, the decrease in the unemployment probabilities was more modest and commenced only at age 30. The data portrayed that the unemployment of men was generally more volatile than the unemployment of women (see Figure 7.1.2). In addition, the peak of unemployment at youth was more distinct among men compared to women. For older men and women, Figure 6.5 displays that the increase in age limit of the 'unemployment tunnel' from 55 to 57 decreased unemployment in that age-interval. For women the effect of the increase in the age limit of the 'unemployment tunnel' was supplemented by the generally decreasing unemployment of women.

The small positive development in young men's unemployment up to the end of the study period was counteracted by a concurrent increase in the probability of belonging to the economically inactive population (Figure 6.6).

Figure 6.3

Line plots of estimated employment probabilities given by one-year age intervals for men and women in years 2000 and 2010. Note the probability that an individual is employed at age x can be interpreted as a working-life expectancy from age x to x +1 years, with x = 15,...,64.

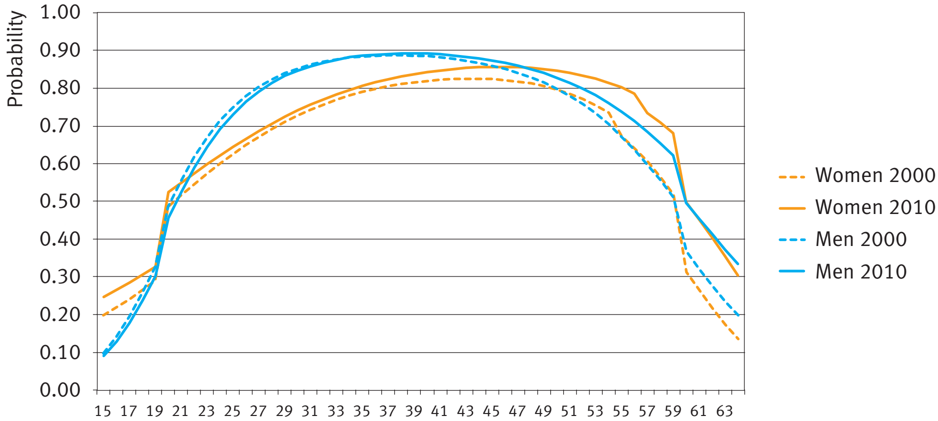


Figure 6.4

Bar plots of the change in the probability of employment (vertical axis) from age 15 by one-year intervals up to 64 years (horizontal axis) for men and women in years 2000–2010. Note the probability that an individual is employed at age x can be interpreted as a working-life expectancy from age x to x +1 years, with x = 15,...,64.

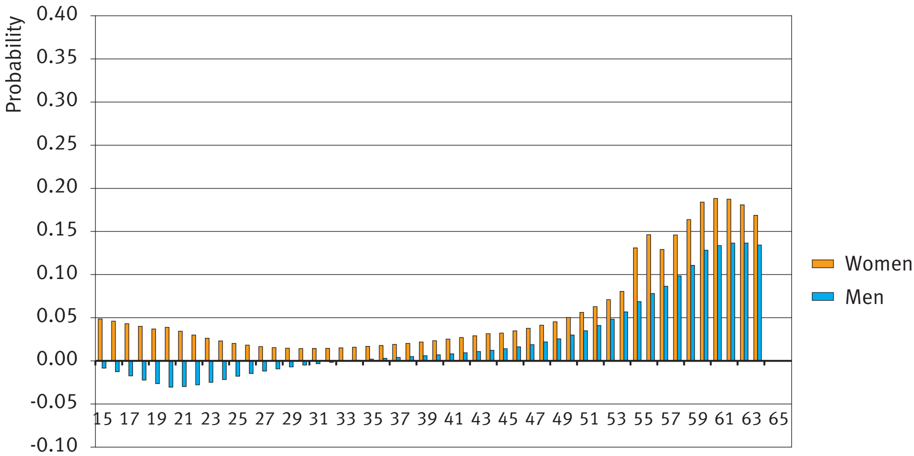


Figure 6.5

Line plots of estimated unemployment probabilities given by one-year age intervals for men and women in years 2000 and 2010.

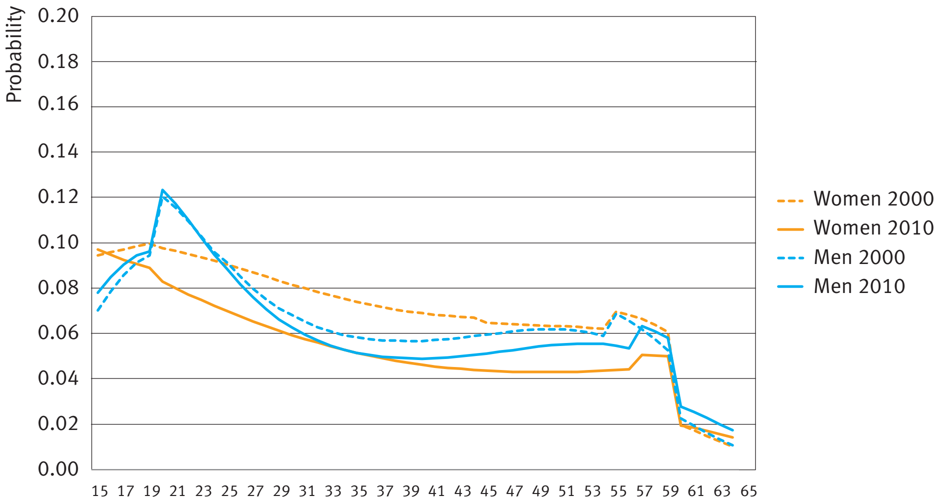
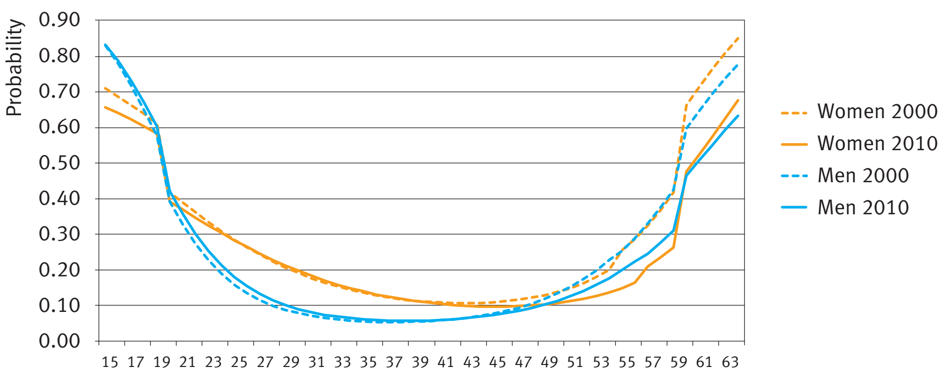


Figure 6.6

Line plots of estimated probabilities of the state 'economically inactive' given by one-year age intervals for men and women in years 2000 and 2010.



7 Estimates of partial life expectancies

In the previous section, the probabilities of the employment and related state probabilities were estimated. Upon integration of these probabilities we derive the corresponding estimates of the components of the partial life expectancy. In the context of this analysis, the term partial life expectancy refers to the *sum* of the working-life expectancy and the expectations of time spent in the states 'unemployed' and 'economically inactive'.

The results naturally depend on the chosen model and have to be interpreted with caution. The correct statistical construction of the model form is important for precision, but, more importantly, to produce accurate (unbiased) estimates the essential factors should be represented in the model.

This section begins by presenting general development of the annual trends in the constituents of the partial life expectancies between the years 2000–2010. It then focuses on the age-related changes over the study period. Finally, the analysis is followed by an examination of the differences by level of educational attainment. Throughout the presentation of the results, we pay special attention to gender differences.

7.1 General development

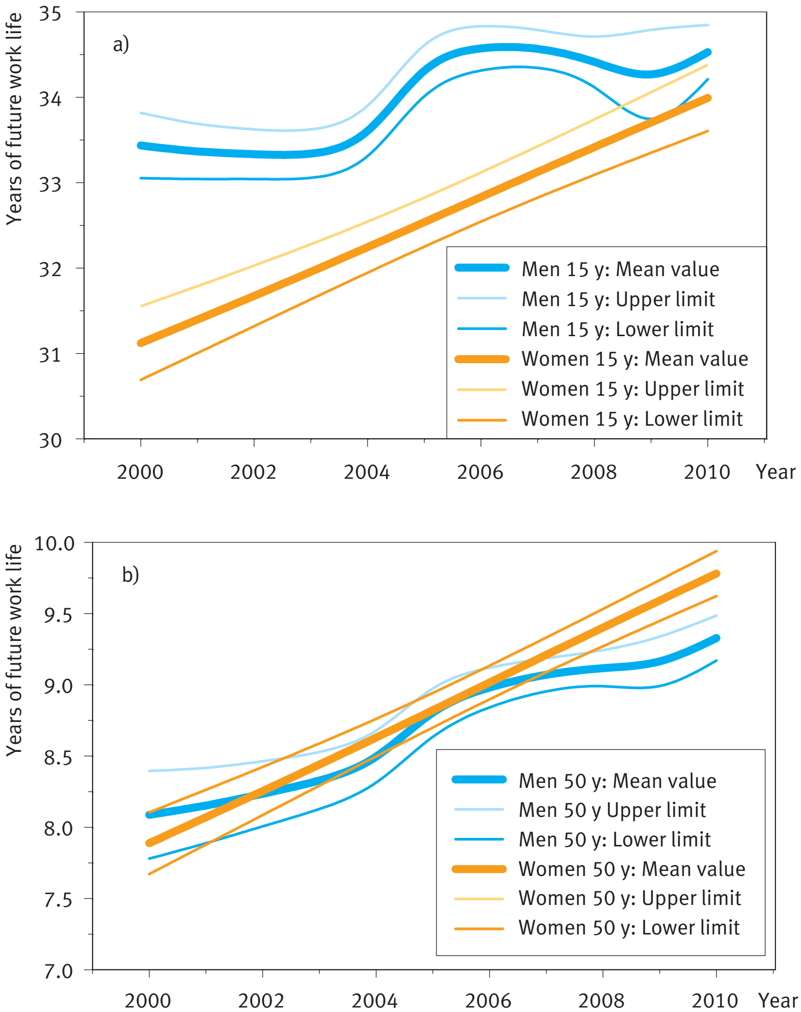
7.1.1 Annual trends

Working-life expectancies generally improved during the years 2000–2010 in all age groups and for both genders. The estimates of the expectancies of the three states 'employed', 'unemployed' and 'economically inactive' are presented in Tables D.1 and D.2 and in Figures 7.1.1, 7.1.2 and 7.1.3.

When comparing men and women, the trend toward longer working-life expectancies is more apparent among women. Figure 7.1.1 shows the male and female working-life expectancy plots at ages 15 and 50. In the 11 year period, the increase in estimated working-life expectancies was greater among women compared to men both at young and advanced ages. For instance, the working-life expectancy for 15 years old grew by 1.1 years for men and by 2.7 years for women from 2000 to 2010. For females the plots depicted straight line trajectories with an ascending slope. The gain in working-life expectancies was more modest among men, but also the male working-life expectancies were higher during the latter half of the study period compared to the earlier half. Moreover, in case of men, there is a small downward dent in the working-life expectancies for 2009, but no bend for expectancies of women. This is an aftermath of the recession in Finland between 2008 and 2010 which affected especially men's employment.

Figure 7.1.1

Spline plots of the working-life expectancies for Finnish men and women at ages (a) 15 and (b) 50 years up to 64 years from year 2000 to 2010. The plots are spline function estimates of the data points, $\hat{e}_1(x)$ showing mean values by boldface solid line, with 95 percent probability intervals (upper and lower limits) shown by thinner lines.



Considering all working-age years from 15 up to 64, the working-life expectancy was still slightly greater in 2010 for men, 34.6 years, than for women, 34.0 years. However, the gender difference had diminished over the 11-year period from 2.4 years to merely 0.6 years in favour of the men. We measured the imprecision of the year 2010 working-life expectancy estimates for 15 year-olds by the 95 percent confidence intervals, whose ranges are 34.3–34.8 for men and 33.6–34.4 for women. The intervals are narrowest in the middle of the observation period and spread out broader toward the peripheral areas.

Focusing on the age groups, the gender difference in working-life expectancies was reversed. For example, the estimates of employment time between ages 50 to 64 in year 2010 were significantly longer for females than for males: $\hat{e}_1^{F,2010}(50)$ = 9.8 years (95% interval 9.6–10.0) *versus* $\hat{e}_1^{M,2010}(50)$ = 9.3 years (95% interval 9.2–9.5).

By definition, changes in working-life expectancy are complemented by corresponding changes in time spent unemployed or outside the labor force.

Figure 7.1.2 shows the expectancies of unemployment time at given ages and for both genders. For both men and women, the expected unemployment decreased from year 2000 to 2010. A noticeable difference between men and women is that, for men, the unemployment time expectancy shows greater volatility associated with economic cycles. For men, the plots of the expected unemployment durations increased during periods of economic downturn in 2001–2003 and the recession in 2009. In comparison, the unemployment expectancies of their female compatriots declined rather linearly by approximately one year in the displayed age groups of 15 and 25 years over the period 2000–2010.

The difference between genders in the volatility of unemployment time may be partly influenced by different model specifications for men and women. The model for men includes a term for annual change of volume of *GDP*, modified by age-specific prevalence. While the term was statistically highly significant for modeling men's unemployment probabilities, the corresponding term was not statistically significant for women and was excluded from the women's model. The difference in model specification may accentuate the gender difference to some degree as the exclusion of the *GDP* term practically eliminates the cyclical fluctuations in estimated unemployment probabilities for women.

Figure 7.1.2

Spline plots of the expectancies of unemployment durations for Finnish males and females at ages x = 15, 25, and 50 years up to 64 years from year 2000 to 2010. The lines are spline function estimates of the data points, $\hat{e}_2(x)$.

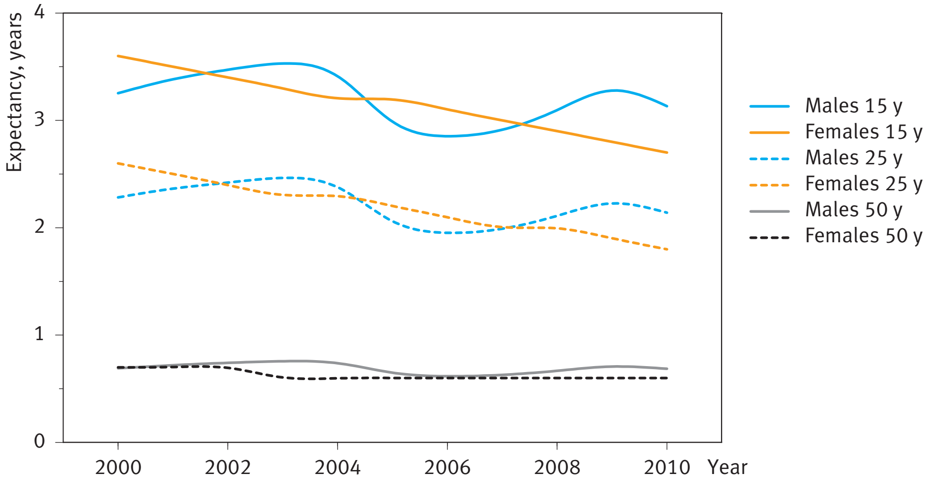
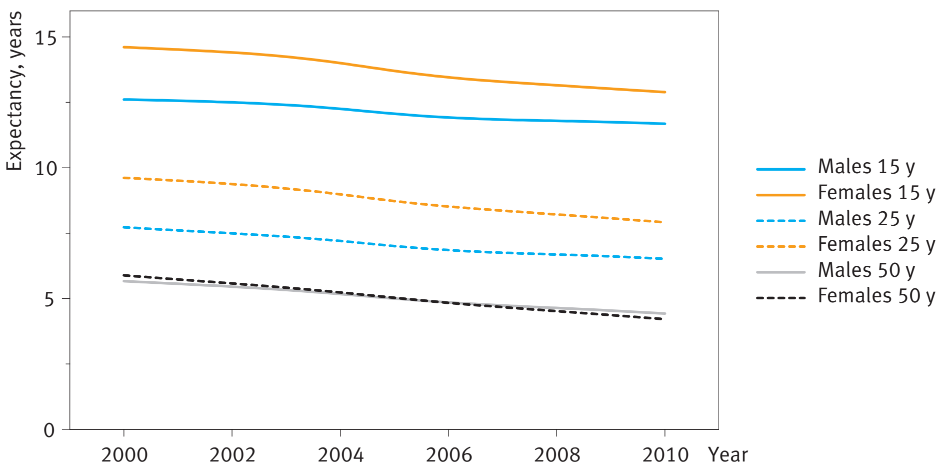


Figure 7.1.3

Spline plots of the expectancies of economically inactive time for Finnish males and females at ages x = 15, 25, and 50 years up to 64 years from year 2000 to 2010. The lines are spline function estimates of the data points, $\hat{e}_3(x)$.



In Figure 7.1.3, the plots of the expectancies for being 'economically inactive' present consistently downward trajectories for both genders over these years. While economically inactive time over the working-age years (from 15 to 64) is generally greater for women compared to men, the gender difference decreased during the study period. From year 2000 to 2010, the expectancy of economically inactive time for 15 year-old women decreased by 1.9 years from 14.7 to 12.8 years, and by 0.9 years from 12.6 to 11.7 years for men. Meantime, the gender difference was reduced by almost half, from 2.1 years to 1.1 years.

When expectancies are computed for higher ages, the gender differences shrink and become even inverted (see also Tables D.1 and D.2). Thus, the gender gap created by greater investment of time to education and childcare by women accounts only for the early half of the working-age years.

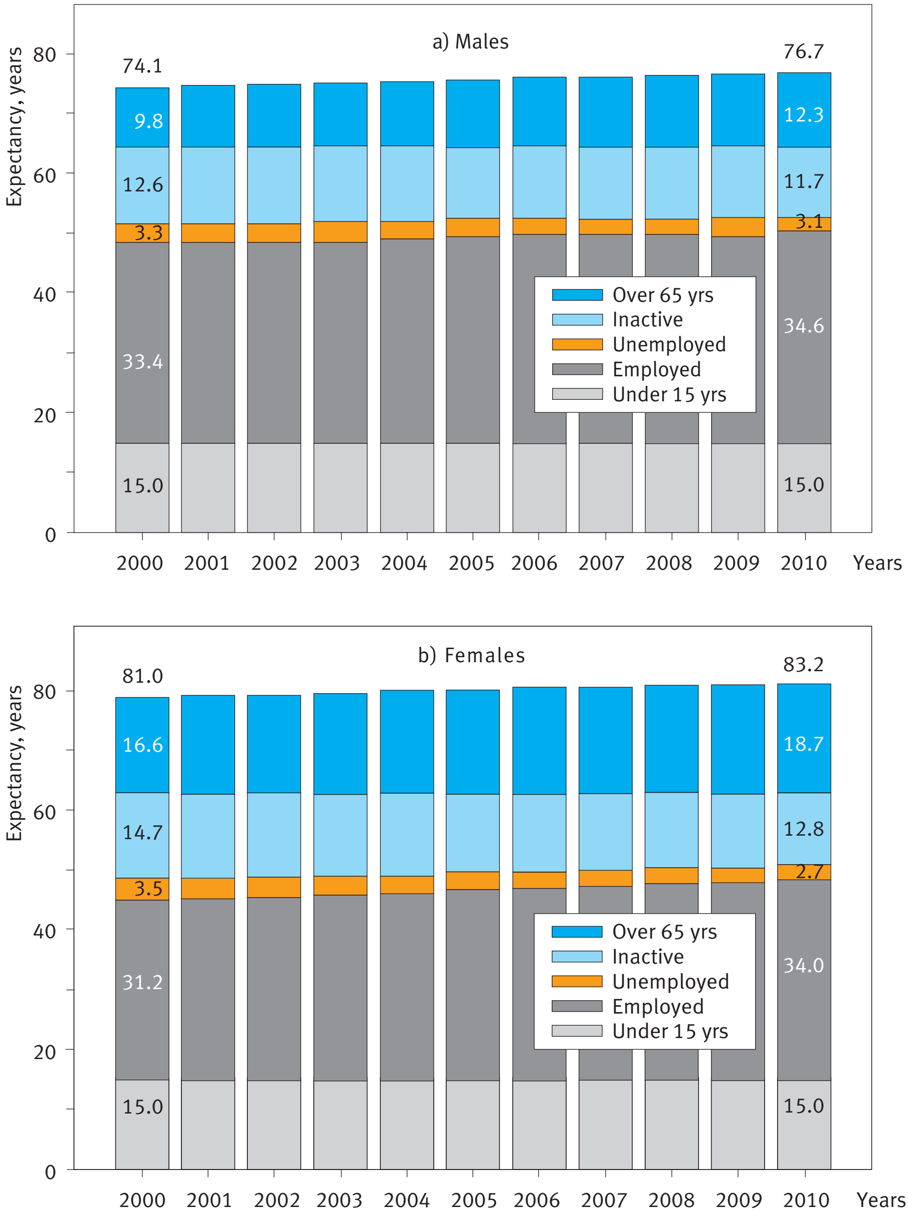
To put these findings into a more general perspective, the bar graph in Figure 7.1.4 presents the life expectancies and the elements of the partial life expectancies for Finnish men and women in 2000–2010. The height of the bar stands for total life expectancy divided into four consecutive phases. The tacit assumption – made for the sake of simplifying the graphical presentation – is that there were no intermittent periods of unemployment, leave, disability, or retirement. The ≥ 65 y portion of the bars represents for the most part the years spent in retirement, which in 2010 was 12 years for men and 19 for women.

The proportion of time in employment between ages 15 to 65 years increased in the 11-year period from 2000 to 2010 for both genders. Although there was only a modest excess in the male life expectancy (+2.6 y) compared to the female figure (+2.2 y), the duration of remaining working life at age 15 grew much less for men (+1.2 y) than for women (+2.8 y).

These trends run counter to the negative development in the preceding two decades from 1981 up to 2001: While the life expectancy at birth grew markedly more for men (+5.1 y) than for women (+3.7 y), the working-life expectancy at the age of 25 years decreased for both genders, and even more for males (-4%-points) than for females (-3%-points) (Nurminen 2008, Figure 6).

Figure 7.1.4

Components of partial life expectancy and total life expectancy for Finnish (a) male and (b) female populations in 2000–2010.



7.1.2 Age-specific changes

The previous Section 7.1.1 presented a generally improving trend of working-life expectancies during the years 2000–2010. In this section, we pinpoint to changes in working-life expectancies computed for given age-intervals among the young and the old. Recognize that employment probabilities derived in Section 6 may also be interpreted as single-year working-time expectancies, and thus they represent an age-decomposition of the total working-life expectancy.

For men during the study period the positive change in the employment probabilities was present at ages 35 and above (Figure 6.3). However, the development of the probabilities of men aged below 30 ended up being negative, whereas among young women, the change was on the positive side. The positive change among middle-aged and older men (gain in average employment time 1.5 years) was thus counteracted to some degree with the negative development among young men (loss in average employment time 0.3 years), resulting in 1.2 years net gain in the total working-life expectancy. Half (median) of the 1.5 years gross gain in the employment time of men was acquired at the age of 59 and above, and three quarters (75%) of the increase was gained at the age of 55 and above.

Among women, the oldest age groups made the greatest contribution to the increase in the total working-life expectancy (Figure 6.4). Half (median) of the 2.7-year increase in the total working-life expectancy of women was acquired at the age of 56 and above, and three quarters (75%) of the increase was gained at the age of 45 and above.

Although the model specified in the study treats the partition of the labor market states mutually exclusively and non-hierarchically, the states of 'unemployed' and 'economically inactive' are, in fact, mutually related and, in part, substitute each other. This is particularly relevant regarding the youngest and oldest in working-age cohorts. In the *LFS* data, an older person made redundant is classified as unemployed only if he or she is actively seeking for work. Otherwise, the person is defined as economically inactive. A specific parameter in the model relating to this phenomenon is the 'unemployment pension tunnel' indicator (Table 5.1 and 5.2).

In the model specified for women, the beta coefficient of this 'unemployment tunnel' indicator was significant and equally large both for the state 'unemployed' and the state 'economically inactive', suggesting that older women made redundant are often discouraged from seeking work. Recall that the effect was shown in Figures 6.5 and 6.6, where the probabilities of both being unemployed and economically inactive fold for women at the ages of 55 (year 2000) and 57 (year 2010) were elevated. Together, the high volatility of young men's unemployment according to economic cycles and increased withdrawal from the labor force to the economically inactive population explain the negative development in the employment expectancy of men below age 30 y.

During economic downturns, the unemployment of young men also pounced steeply upwards (Figure 7.1.2). The peak male unemployment occurred at the age of 20 years (Figure 7.1.5). In all, the figures suggest that the weak economic growth during the years 2001–2003 and in the recession year 2009 held back the decrease in men's unemployment compared to that of women, particularly in the young age groups.

As already shown in Figure 7.1.3, the total expectancy of an economically inactive time during the working-age years decreased for both genders during the study period. Figure 6.6 further specifies that the decrease in economically inactive time occurred merely in the oldest age groups. The decrease was greater for women than for men, thus contributing to the more favorable development in the working-life expectancy among women compared to men.

As the majority of the increase in the working-life expectancy during the study period was gained at the ages above 50, we present the cumulative changes in working-life expectancies computed at ages 50 through 60, expressed as absolute and relative differences in Figures 7.1.6 and 7.1.7, respectively. With the year 2000 as the reference year, the cumulative change up to the year 2004 represents the earlier half of the study period, before the enactment of the 2005 pension reform. The latter period measures the change from year 2005 to 2010. The lines marking the absolute difference naturally show steadily declining age-trends for both genders. A comparison of the absolute differences in expectancies in the earlier period to those in the latter period illustrates that the changes for females (in the range of 0.50–0.60 *versus* 0.34–0.67 years) were larger than the corresponding ones for males (0.20–0.36 *vs.* 0.27–0.48 years). However, expressed in relative terms, from year 2000 to 2010 there are steeply ascendant curvatures from age 57 onwards for women (with differences of 18.6–86.5 percent over the 11-year period) and a more moderate increase for men (15.5–46.6 percent). This favorable development may be partly due to the pension reform.

Figure 7.1.5

Bar plots of the unemployment expectancies for Finnish males grouped at ages x = 15 through 29 years during economic downturn in 2003 and recession in 2009, with year 2007 as a reference. The heights of the bars represent estimates of the data points, $\hat{e}_2(x)$, calculated for one-year age intervals. The low unemployment at the age of 18 is due to military service that is counted as inactive time.

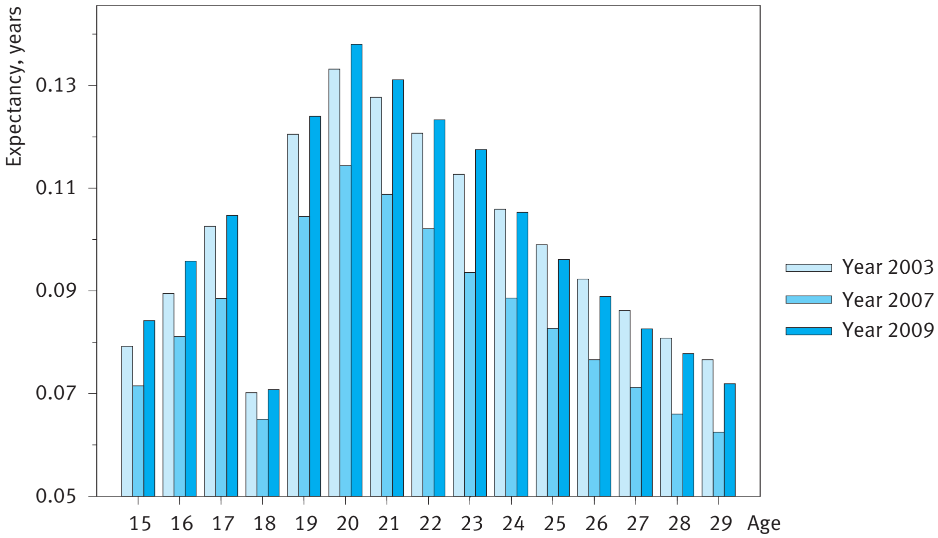


Figure 7.1.6

Spline plots of the working-life expectancies for Finnish (a) males and (b) females at ages x = 50 through 60 years, five years and one year before (2000, 2004) the pension reform was enacted (in 2005), and five years thereafter (2010). The lines are spline function estimates of the data points, $\hat{e}_1(x)$.

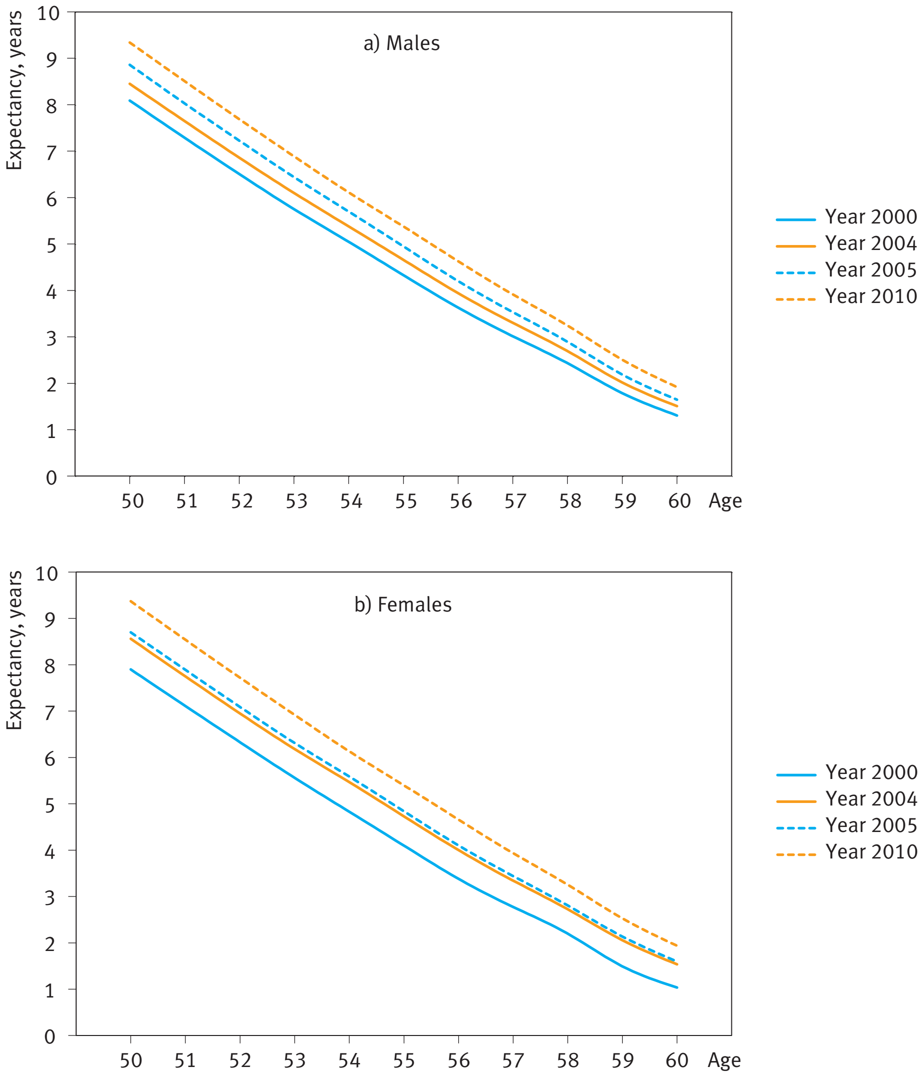
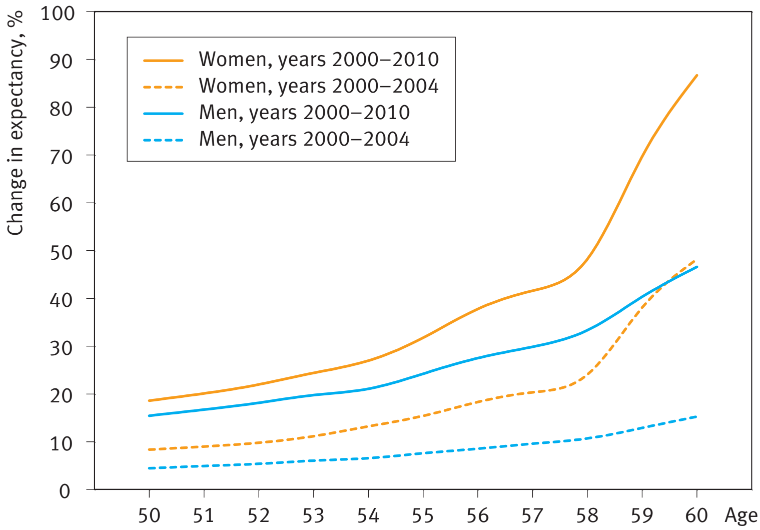


Figure 7.1.7

Spline plots of the percentage differences of working-life expectancies from the year 2000 (reference year) to the year 2004 and 2010, expressed for Finnish females and males at ages x = 50 through 60 years. Expectancies are computed up to the age of 64. The lines are spline function estimates of the data points, $\hat{e}_1(x)$.



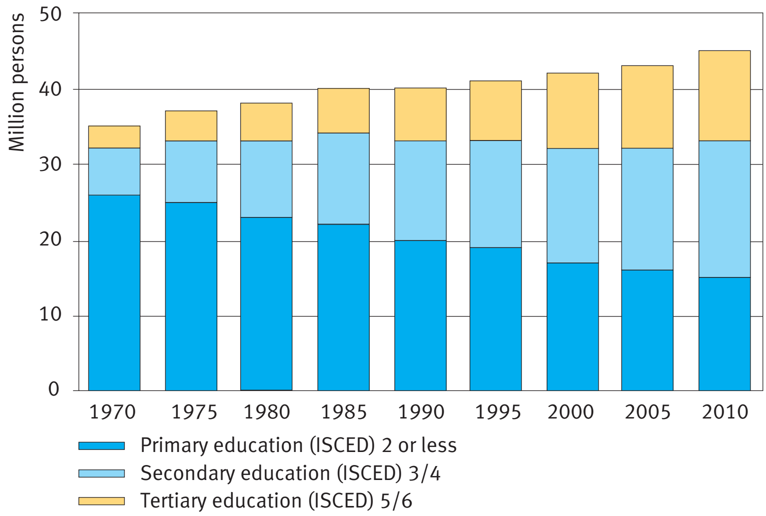
7.2 Educational differentials

In this section we calculate partial life expectancies categorized by education. Two specific questions are examined: Is educational attainment differently associated with the expectancies? Does education have a bigger impact on the expectancies of either gender?

The expected working-times according to a person's economical activity status and educational level are presented in brief in Table 7.2.1 and in Figures 7.2.2, 7.2.3, 7.2.4 and 7.2.5, and in detail in Tables D.3 and D.4.

Figure 7.2.1

Population aged 15 or over by level of education 1970–2010.



Source: Education 2011. Statistics Finland.

The size of Finnish population with educational qualifications has multiplied over the past 40 years, and it has continued to expand in the 2000's (Figure 7.2.1). In 2010, the share of working-age population having completed only primary level of education numbered 1.13 million, that is 27.9 percent of the population. Secondary level qualifications were held by 41.6 percent and tertiary level qualifications by 30.5 percent.

Among the over 55-year-old employed persons those with only primary level education has decreased in the last decade from 41.5 percent to 25.3 percent. On the other hand, the share of employed who had acquired tertiary level education has grown from 31.8 percent to 37.4 percent.

Table 7.2.1

Working-life expectancies[8] for 15-, 20-, 25- and 50-year-old male and female workers by level of educational attainment and gender in Finland 2010.

Level of education	Males							
	15 y	Difference*	20 y	Difference	25 y	Difference	50 y	Difference
Primary	30.3	0	29.4	0	26.6	0	7.8	0
Secondary	34.5	+4.2	33.3	+3.9	30.1	+3.5	8.7	+0.9
Tertiary	37.9	+7.6	37.7	+8.3	34.1	+7.5	11.0	+3.2
	Females							
Primary	26.1	0	24.9	0	22.6	0	7.9	0
Secondary	34.8	+8.7	32.0	+7.1	29.0	+6.4	9.6	+1.7
Tertiary	36.0	+9.9	35.8	+10.9	32.1	+9.5	11.1	+3.2

* The difference in expectancies is subtracted with primary level as the baseline status.

Previous studies have shown that more advanced education enhances a person's chance of staying longer in employment and postpones his or her permanent exit from labor force (Myrskylä 2009; Järnefelt 2010). To reconfirm these observations in the total Finnish population, we employed a measure of the level of educational attainment (OSF 2011c) and tested the associations in the present data by means of working-life expectancy.

Table 7.2.1 evinces that with an increasing level of education the expected remaining time in employment becomes longer, and this fact is obvious already at an early phase of the working career (from age 15 to 25). At ages 15, 20 and 25 years the differences (tertiary *versus* primary level education) are conspicuously large, around 7.5 years for men and close to 10 for women. Even at the age of 50, this discrepancy in expectancy persists, being 3.2 years.

It is also informative to calculate the *differences* in working-life expectancies between ages 15 and 20 years in Table 7.2.1. This gives us estimates of the expected gain that teen-aged persons accrue at the start of their working career. (The earliest age when work starts is at the age of 15 for persons with a primary-level education, 17 years for those with secondary-level and 20 for those with

8 Working-life expectancies are counted from age 15/25/50 up to 64 years, assuming that a worker permanently retires from the workforce no later than on his or her 65th birthday. The actual retirement age is also measured through the expected effective retirement age. More detailed information on this indicator is available at the following publications of the Finnish Centre for Pensions: Effective retirement in the Finnish earnings-related pension scheme, *Eläketurvakeskuksen tilastoraportteja* 4/2008; Expected effective retirement age in the Nordic countries, *Statistical Report* 2/2008.

a tertiary-level education.) At the three educational levels the differences from age 15 to 20 are for males/females 1.0/1.2, 1.3/2.8 and 0.2/0.2 years, respectively. For example, $\hat{e}_1^{M,2010}(15) - \hat{e}_1^{M,2010}(20) = 30.3 - 29.3 = 1.0$ y. Evidently, for both genders persons having tertiary education by age 20 years have only gained work experience a couple of months, whereas those with primary or secondary education have already participated in working life for over a year.

The problem in the interpretation of these gain figures is that all persons under age 25, including those who will be oriented to secondary and tertiary education, are in the group with primary education. In other words, those who are studying at the secondary level belong to the primary education group and those who study at the tertiary level are in the secondary group. Thus, it is realistic to assume that a rather significant share of the primary-level employed youngsters are persons who are studying for a higher level degree; some of them work and study concurrently or work intermittently between study years.

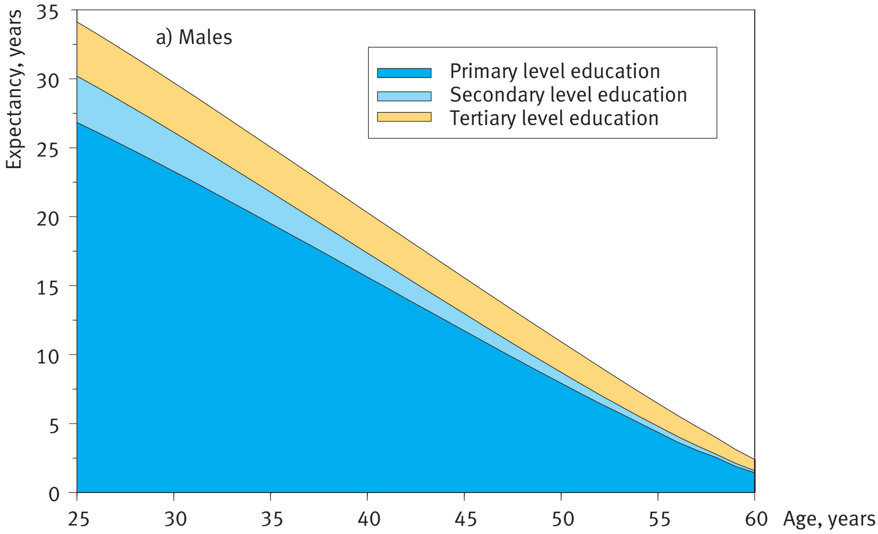
In Figure 7.2.2, the working-life expectancies for persons with a low educational level are plotted along the age axis with the expected *additional* years spent in working life for middle and high educational level ‘stacked’ on top of the preceding ones. For example, at age 25 years in 2010, an ‘average’ male worker with a primary-level education was expected to be employed for 26.6 years, for 3.5 (= 30.1 – 26.6) additional years with a secondary-level education, and an added 7.5 (= 34.1 – 26.6) years with a tertiary-level education (Figure 7.2.2a). The expected number of additional working-life years brought by secondary- and tertiary-level education is more pronounced among females (Figure 7.2.2b).

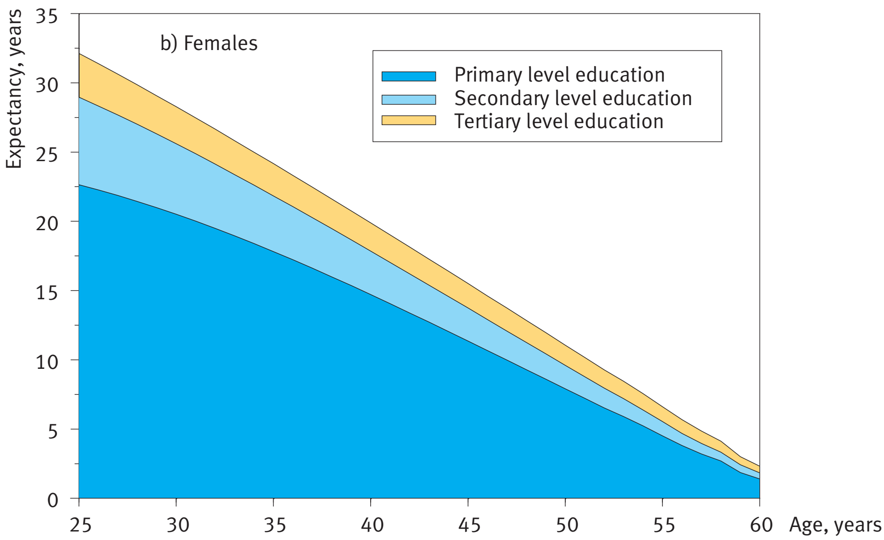
Note that the partial life expectancy, *i.e.* the sum of the expectancies for the three labor market states (employed, unemployed and inactive), adds to the duration of a maximum considered time interval. For example, for males possessing only a primary level education in 2010, the partial life expectancy is estimated from the starting age of 25.5 years to the limiting age of 65 years. This span is 39.5 years, 65 – (25 + 0.5) = 26.6 (employed) + 3.3 (unemployed) + 9.5 (other) years (Table D.3).

The additive partition of the working-life expectancies in relation to the specified levels of education is an attractive graphical presentation and has methodological appeal. The decomposition is helpful in understanding at what ages changes in a person’s working life occur and in quantifying those transitions conditionally on the level of education.

Figure 7.2.2

Additive area charts of working-life expectancy of Finnish (a) men and (b) women at ages 25 to 60 up to 64 years in 2010 by their attained level of education.





Working-life expectancies by level of education have been plotted separately for males (Figure 7.2.3a) and females (Figure 7.2.3b). For either gender and at both ages, the fitted lines are located horizontally at levels corresponding to the ranking of the level of education. In other words, those persons with a tertiary level of education occupy the highest position, those with a primary level lie lowest and the ones with a secondary level are placed intermediate.

The general developments for women are that at a tertiary level of education, the annual time series are fairly stationary for the 25-year age group, whereas at the secondary level, the lines have an upward inclination, and at the primary level they tend to bend downward. In case of males, there appear to be small elevations at all educational levels in the working-life expectancies since 2005 and also a discrepant drop for males with a secondary level education in the expectancy in the recession year 2009 (Table D.3). For the working-life expectancies at age 50+ years, there appear to be no notable irregularities.

A particularly favorable development in the working-life expectancies was seen among women with a secondary level education whose expectancies at age 25 years increased over the past decade by 2.5 years (Figure 7.2.3b). The corresponding increase at age 50 was from 8.0 to 9.6 years (+20 percent).

Figure 7.2.4 shows the expected time spent in unemployment at the three levels of education for both genders. While the bars for females at the age of 25 decline steadily over the decade, for men the expectancies increase slowly. Moreover, since 2005 the male unemployment times are shorter compared to the years preceding 2005. At age 50, the female unemployment expectancies remain roughly the same over the years. For males with primary education the unemployment expectancies are not longer than for those with secondary education.

The remaining time that a 25-year-old person is expected to stay outside of the workforce is visualized in Figure 7.2.5 at the three levels of education for both genders. The higher the education achieved, the less time he or she is likely to be economically inactive. Moreover, men have more favorable expectancies than women at all levels. In particular, women with primary level education tended to abide increasingly longer time in economically inactive life in the last decade. On the other hand, men possessing a tertiary education were consistently more actively engaged in working life with the passing of time from 2000 to 2010.

Figure 7.2.3

Spline plots of the working-life expectancies by level of education for Finnish (a) males and (b) females at ages 25 and 50 (integrated up to 64) years from 2000 to 2010. The lines are spline function estimates of the probability densities of the data points, $\hat{e}_1(x)$.

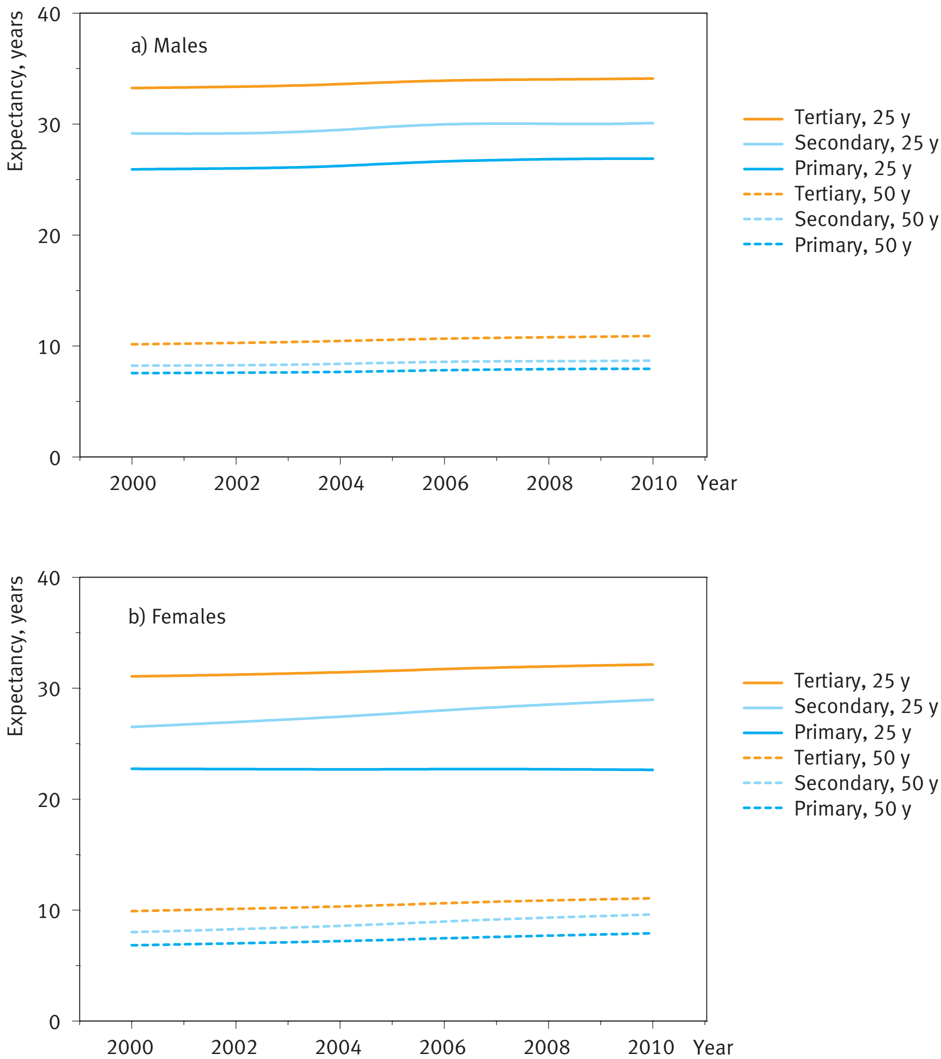


Figure 7.2.4

Multipanel bar plots of the expectancies of the unemployment time by level of education by gender at ages 25 and 50 (integrated up to 64) years from 2000 to 2010. The bars are model-based estimates of the data points, $\hat{e}_2(x)$.

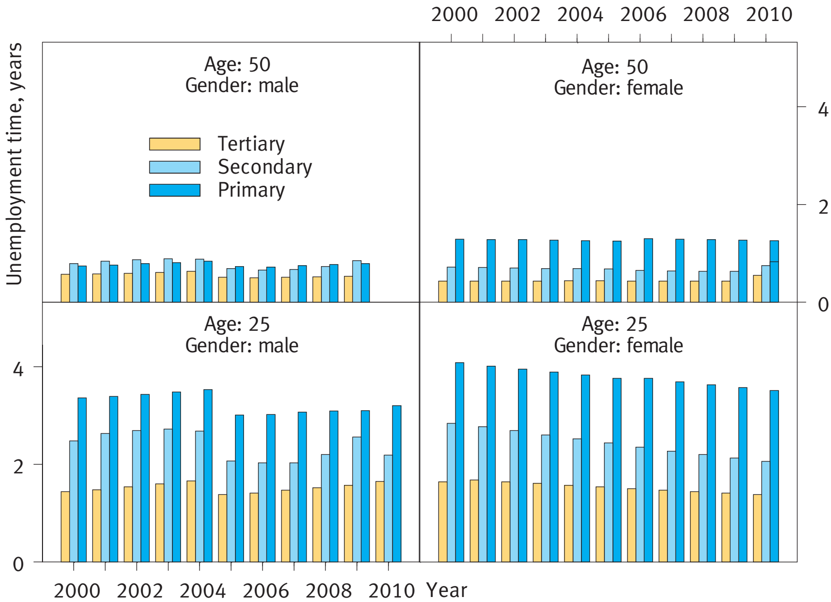
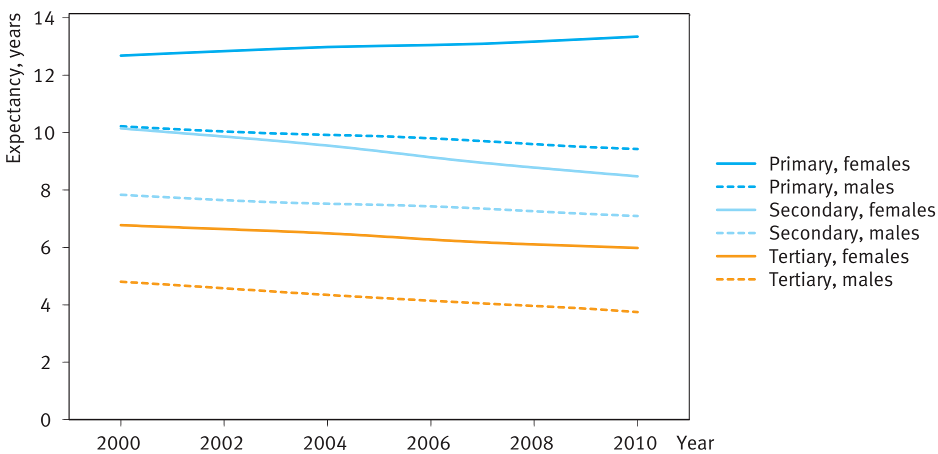


Figure 7.2.5

Spline plots of the expectancies of the economically inactive time by level of education for Finnish males and females at age 25 (integrated up to 64) years from 2000 to 2010. The lines are spline function estimates of the probability densities of the data points, $\hat{e}_3(x)$.



8 Forecasts of working-life expectancies

It is possible to make predictions of the working-life expectancies from the estimates $\hat{e}_1(x)^{2000},\dots, \hat{e}_1(x)^{2010}$, for ages $x = 15,\dots,60$, that were obtained by fitting a generalized linear model and by applying the PREDICT.GLM function of S-PLUS. We extracted the parameter estimates from the fit and computed the variance of the residuals. The model-based extrapolations were projected for the years 2010–2015 using the preliminary values of *GDP*: 3.7, 2.9, 1.0, 1.2, 2.1, 2.2 (source: Statistics Finland, Ministry of Finance 2012). The forecast is based on the assumption that the economic growth will not be hampered by a downward cycle setting in. The *GDP* growth figures applied in the present prediction had greater variance than those used in the previous prediction (Nurminen 2011), indicating the exceptional uncertainty in the current economic outlook for Finland. The forecasts and their 90 percent point-wise prediction intervals are presented graphically in Figures 8.1 and numerically in Tables E.1 and E.2.

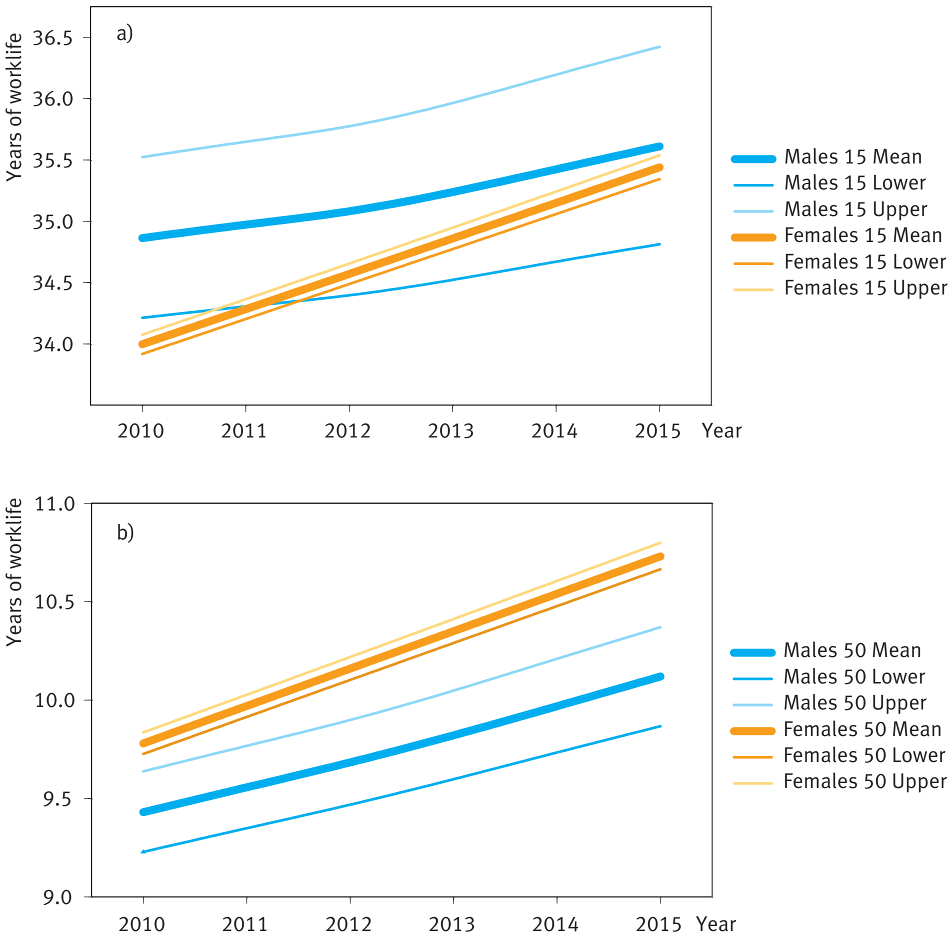
To check the validity of the prediction model, the working-life expectancies retrospectively predicted for the baseline year 2010, $\hat{e}_1(15)^{M,2010} = 34.9$ (34.2–35.5) and $\hat{e}_1(15)^{F,2010} = 34.0$ (33.9–34.1), concur well with the values estimated using the present model from observations including 2010: $\hat{e}_1(15)^{M,2010} = 34.6$ (34.3–34.8) and $\hat{e}_1(15)^{F,2010} = 34.0$ (33.6–34.4). The slight discrepancy in the male figure is likely due to the fact that the exceptional recession year 2009 was at the end of the observed data range, and that the recovery of employment in 2010 was tardier than anticipated.

The predicted durations of working lives for 2015 are longer than those estimated for 2010: for males, the increase is one year, 35.6 (90% prediction interval, 34.8–36.4) years; for females 1.4 years, 35.4 (35.3–35.5) years. The male prediction $\hat{e}_1(15)^{M,2012} = 34.6$ years equals the estimate $\hat{e}_1(15)^{M,2007} = 34.6$ years. This follows from the development of economic output, which is forecasted not to recover to its previous, pre-recession peak levels of late 2007 until 2014. Employment will improve rather slowly with the economic rebound, and no significant contraction is expected in the labor force (Ministry of Finance 2012).

The age- and gender-specific developments are clear. At ages 15 to 30 years, the male working-life expectancy stayed consistently at a higher level than that of females from 2011 to 2015. For women, the trend ensued a straight line. When people reach the age of 40 years, the predicted female expectancy supersedes that of males throughout the prediction period. In general, the width of the prediction

Figure 8.1

Spline plots of predicted mean future years of employment drawn by boldface solid line, with pointwise 90 percent prediction intervals (lower and upper limits) by thinner lines, for (a) 15- and (b) 50-year-old men and women given for the years 2011–2015, with the year 2010 as a baseline.



intervals is broader toward the end of the period. The intervals for men are wider than those for women due to the greater volatility in male expectancies in the past decade.

An important finding is that, for men aged 15 in 2015, the predicted future duration of employment was estimated to be 35.6 years, for women 35.4 years. These projections coincide with the expected value of 35.5 years for both genders combined (computed at the Finnish Centre for Pensions using the Sullivan method) that would be needed in the development of the length of working careers, if the ratio of the time spent on pension to that at work would remain constant with the elongation of general male life expectancy (Laesvuori 2010).

For more on forecasting and setting prediction intervals, consult Appendix E.

9 Discussion

In this report stochastic procedures were applied to model, estimate and analyze employment processes encountered in working-life, and to make inferences and forecasts based on the results. This report has been concerned with the quantification of the length of people's careers and their differentials in terms of the working-life expectancy. Although the results are specific to Finland, the questions concerning the development of time spent in employment and its measurement are relevant for a broader audience.

Stochastic process analysis has been applied previously for estimating the expected time in employment in the 1980s and 1990s. Now we can present results for the first decade of the 2000s. In this section, we first briefly review the experience gained over a period of three decades. Secondly, we compare the estimates of working-life expectancies calculated using different methods and finally explain the reasons for discrepancies between results.

9.1 Previous studies and present results

Figure 9.1.1 presents a time series spanning three decades that has been formed by joining the working-life expectancies obtained from two separate studies for the periods 1981–2001 (Nurminen *et al.* 2005) and 2000–2010 (present study). The datasets were obtained from the same source, *viz*. Finnish Labour Force Survey, and the statistical methods applied were basically the same. Thus the series provide consistent arrays of estimates even though the regression models incorporate specific features for the two periods.[9]

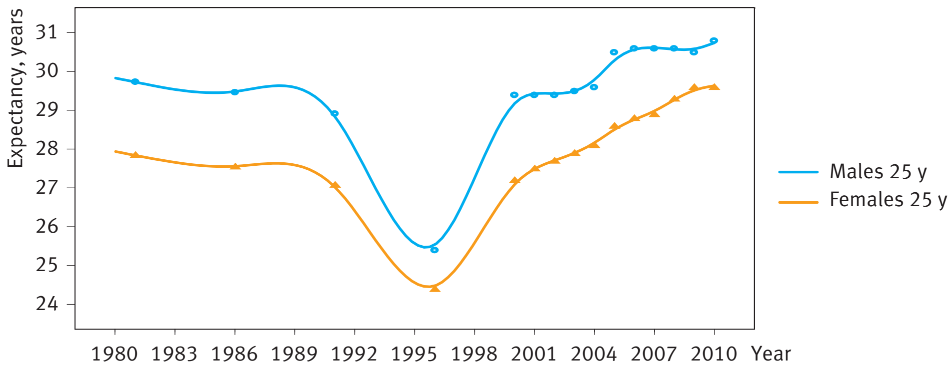
As can be seen, the working-life expectancy at age 25 depicted rather stable developments for both genders in the 1980s. Working life expectancies decreased gradually in the 1980s. Due to the deep recession that lasted over the early years of the 1990s, working life dropped significantly, and with a delay of about three years, reached bottom levels around 1996 (Figure 9.1.2).

The decline in the Finnish working-life expectancies around 1996 was mainly due to high unemployment and increasing popularity of early retirement, which was a major component of the state 'economically inactive' at older ages.

9 In particular, the former study modeled the recession effect from 1993 to 1996 with an indicator function in the log ratio for the employed men and women.

Figure 9.1.1

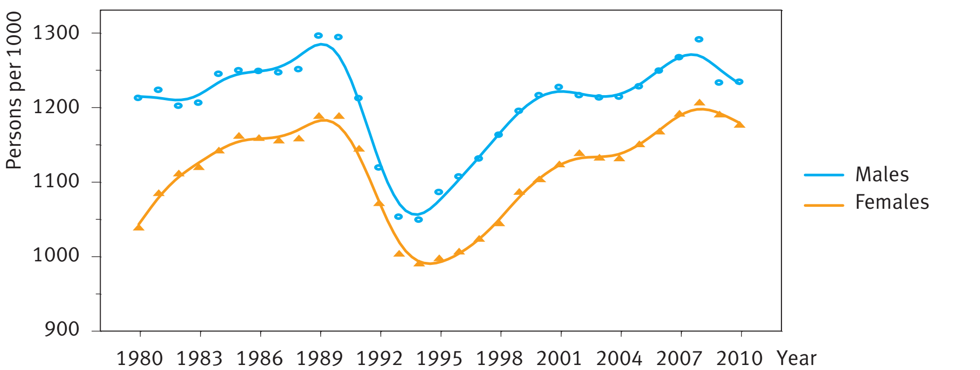
Estimated mean future time of employment, expressed in years, for the Finnish population aged 25 in 1981 through 2010, separately for males and females. Shown are spline plots with point estimates.



References: Nurminen *et al*., 2005; Nurminen 2011.

Figure 9.1.2

Frequencies of employed males and females per 1,000 persons for Finland 1980–2010. Shown are spline plots with point estimates.



Source: Statistics Finland 2011-12-29.

Economic inactivity did not increase due to disability, for which the prevalence decreased sharply in 1996 (Hytti *et al.* 2006, Figure 1).[10] The improvement in working life expectancy came about after the turn of the century. During the decade 2001–2010, the trends point toward longer working careers.

10 A significant determinant for the decrease of the frequency of disability pensions was the gradual abolishment of the individual early retirement pension scheme.

According to the present study, a general development toward longer working careers is evident. During the past decade, the expected future employment time increased in all age groups and for both genders. The life expectancy of Finnish men grew in 2000–2010 by 2.6 years and by 2.4 years for women. The respective increases in working-life expectancies were 1.2 years for men and as much as 2.8 years for women. Concurrently, the economically inactive time has decreased significantly: among men 0.9 years, and among women 1.6 years.

In 2010 for a 15-year-old man the estimated average length of working career up to age 64 was 34.6 (95% confidence interval, 34.3–34.8) years, while for women it tailed at 34.0 (33.6–34.4) years. There was an increase of 10 percentage points or more in the working-life expectancies in the study period for females starting already at age 30 and for males from age 45 on.

With the help of the data and the method employed, our study could point to some important differences between men and women and across educational levels. While men's working life expectancies have previously exceeded those of women, the female expectancies have improved and exceeded the male figures since 2008 in the over 40-year age groups. The relatively favorable total employment situation in Finland compared to the other EU countries has earlier been based on the fairly high employment rate among women, and the new results would seem to predict that women will support the Finnish employment rate even stronger. The inferred difference in probabilities and working-life expectancies between the genders is an interesting finding and worth further research.

Our results on educational differences also showed major differences. According to statistics (source: EU-commission, Eurostat 2011), the employment rate clearly rises by the highest level of education attained. For the age group 20–64 years, the employment rates by level of education were the following: 54.1 percent for pre-primary and lower secondary education (levels 0–2); 72.5 percent for upper secondary and post-secondary, non-tertiary education (levels 3 and 4); 84.3 percent for first and second stage of tertiary education (levels 5 and 6). In the light of the present study, working life expectancies are patterned accordingly. In Finland the rapid and massive change in the structure of education and work tasks could be a particularly important explanation to the differences found in working careers. The increased level of education, which has risen rapidly also in the older age groups, is strongly correlated with the continuation in work life. Also the employment rate of the 60-to-64-year-olds has almost doubled in just over a decade. In 2000, only 23 percent of that age group was still working, whereas in 2010, nearly 41 percent remained in working life. The jobs that the more educated persons do are more interesting and physically less strenuous than, for instance, those in heavy industry and service professions. People generally bear longer in jobs in which health is not at risk. A low level of education is especially associated with transition to a disability pension (Polvinen 2009).

Combining the gender and education variables, we found that the working-life expectancy for women at age 25 was shorter than that for men at all educational levels. The differences between educational levels were considerable, and greater among women. We estimated that the difference in working-life expectancies between a 25-year-old upper-level white-collar worker and a blue-collar worker in Finland in 2010 was over 5 years (detailed statistics are not shown). However, working-life expectancy cannot be fully explained by socioeconomic status. Again, taking a closer look at the education-related differences and their potential explanations is a task for further research.

9.2 Comparison of life table methods

The methodological interest in this research report has been on the application of inferential tools for discrete time stochastic processes for application to register-based life table data which are readily available. It is contended that this modern approach has multiple advantages over the currently used practices.

Earlier applications of population health measures (Nurminen 2004) such as *active life expectancy* have been numerous, especially in the US (Katz *et al.* 1983), and recently also in Europe (Strulik and Werner 2012). They have been applied also in Finland for employment patterns by the Social Insurance Institution (Hytti and Nio 2004) and for retirement by the Finnish Centre for Pensions (Kannisto 2006).

Our approach to estimating *working-life expectancy* differs from the traditional method in many fundamental facets. Although we also use data from the life tables and the *LFS*s of Statistics Finland, we estimate the working-life expectancies jointly for multiple years throughout the study period. An alternative approach to the analysis is to carry out separate estimations for a series of survey or census years and then fit a curve to describe trends, as was done in Hytti and Nio (2004) in their monitoring of cross-sectional employment activity data over a number of years. The present analysis spans eleven years and a large number of individuals, so the results are not so sensitive to economic conditions as a survey that would rely on only asingle year of data (see Figure 9.2.1).

We base our analysis of panel or cohort data on a large-sample regression model fitted to a multistate life table, instead of a simple relative frequency calculation from the average demographic experiences of artificial cohorts (constructed using an arbitrary radix for the number of survivors at each given age). This stochastic inferential approach allows us to draw probabilistic inferences on several worklife characteristics and also permits much more detailed working-life tables to be estimated, for example stratified by socioeconomic factors. We modeled the state probabilities as a function of age, year, and *GDP*. The set of variates describing demographic and economic conditions faced by persons can be expanded, but not at will. This modeling approach enables one to circumvent the problem of small cell sizes encountered in a modest disaggregation of data.

The traditional prevalence life table technique is limited when applied to intrinsically dynamic processes with multiple decrements, like the labor force process. The life table calculated from prevalence rates cannot provide the occurrence/exposure rates in a continuous time frame. If labor force participation rates change over time, these trends are incorporated more accurately in the multistate life table method than in the prevalence-based technique (Smith 1982). The latter method is rather sensitive to particular fluctuations in labor force activities. Calculations could therefore overstate the labor force involvement at times of expansion and understate it during a recessionary period.

The working-life expectancy measure has been characterized as being sensitive to volatile labor market variations in a report of the working group for lengthening working careers (Prime Minister's Office 2011). For example, in 2008 the Finnish working-life expectancy at age 15 was 34.6 years but it decreased by one whole year due to the rapid decline in employment in the recession year 2009. Actually, this expectancy was computed using the traditional (Sullivan 1971) technique on a year-by-year basis. The multistate regression (Davis *et al.* 2001) approach to expectancy, which is based on fitting a smooth model over the studied interval, herein 2000–2010, does not overestimate the effect of such changes on the total length of working career. In this study, the model yielded the following estimates of male working-life expectancies for the years 2008, 2009, and 2010: 34.5, 34.2, 34.6 (Table D.1). The drop from 2008 to 2009 was only 0.3 years and the counteractive rise from 2009 to 2010 was 0.4 years.

The multistate regression methods were developed to overcome the limitations of the traditional prevalence techniques. The states are defined to be multiple, some of which are transient (or recurrent) while others are assumed non-transient. In this study we enhanced the customary life table by explicitly defining a three-state employment state space: (1) employed (permanently employed, employed for a fixed-term, and self-employed); (2) unemployed; (3) outside the labor force (e.g., students, conscripts, disability and old-age pensioners). This decomposition is different to the two-state system which estimates the duration of 'active working life' by classifying persons as 'active' (in the labor force) or 'inactive' (out of the labor force) (Hytti and Nio 2004). The tabular analysis of further disaggregated data (*e.g.* allowing various modes of exit from the labor force) would necessarily turn out to be cumbersome or impossible without resorting to modeling. The regression analysis of panel or cohort data is applicable when the numbers are reasonably large; frequencies of 10 or more in the non-absorbing cells of the multistate life tables – say at 10 tables – should be sufficient (Prof. C.R. Heathcote, ANU, personal communication, 3.12.2001).

Finally, because working-life tables are generated from survey data, sampling variation may be important (*e.g.*, due to population dynamics, economic fluctuations, interview methods), especially in small samples. Although the Finnish official research institutes acknowledge this fact, they do not provide standard error estimates for their active working life expectancies (Appendix Table 4; Kannisto 2006). Under stationary conditions (*i.e.* independence of an initial health state), a new 'equilibrium' estimate of the prevalence rate and its approximate variance has been developed by Diehr *et al.* (2007). In the Davis *et al.* (2001) approach, standard errors (and covariances) can be found by using the delta method based on the loss function (Appendix A) or alternatively by Monte Carlo sampling from the estimated asymptotic normal distribution of the estimated regression coefficients.

To contrast results obtained with these two different methods, Table 9.2.1 presents working-life expectancy estimates obtained for the age span 15–74 for the years 2000–2010.[11] The regression model-based estimates indicate lesser variation than the corresponding prevalence estimates for both genders. The current working-life table estimates designate large fluctuations especially for males around the economic upturn year 2008. Both series of estimates show lower figures for males in the recession year of 2009 compared to the neighboring years (Figure 9.2.1). The recession affected foremost men's employment. Preliminary statistics point to the fact that the recovery was delayed until 2011 among women. We find that that the absolute difference between the two sets of expectancies has risen and then fallen over time.

11 In 2010, the age group 65–74 years added 1.1 years for men and 0.8 years for women to the working-life expectancy computed for the age interval 15–64 years.

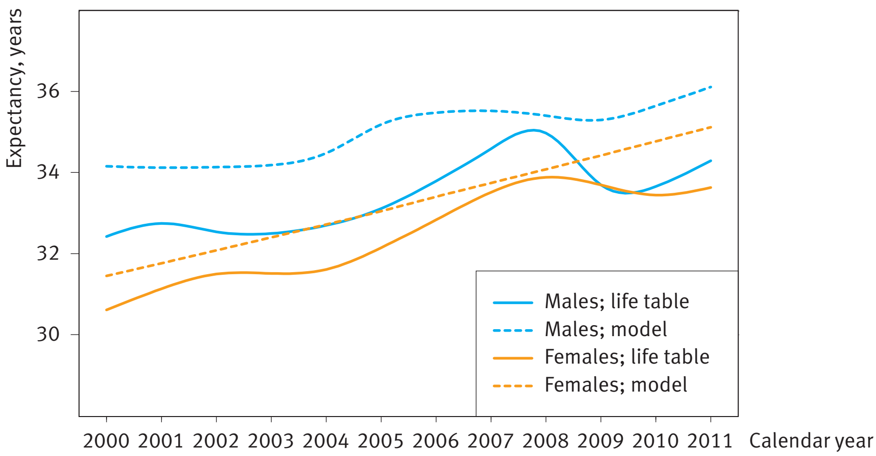
Table 9.2.1

Working-life expectancies, in years, for the age span of 15–74 years in the study period 2000–2010. Comparison of the cohort-type and current life table estimates computed by the methods of Davis et al. and Sullivan, respectively.[12]

Method	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Males										
Davis *et al.*	34.2	34.1	34.2	34.2	34.3	35.3	35.4	35.5	35.5	35.2	35.7
Sullivan	32.4	32.8	32.5	32.5	32.7	33.1	33.8	34.5	35.2	33.5	33.7
Difference	1.8	1.3	1.7	1.7	1.6	2.2	1.6	1.0	0.3	1.7	2.0
	Females										
Method	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Davis *et al.*	31.5	31.8	32.1	32.4	32.7	33.0	33.4	33.7	34.1	34.4	34.8
Sullivan	30.6	31.1	31.6	31.5	31.5	32.2	32.8	33.5	34.0	33.7	33.3
Difference	0.9	0.7	0.5	0.9	1.2	0.8	0.6	0.2	0.1	0.7	1.5

Figure 9.2.1

*Current life table and model-based estimates of working-life expectancy for the age span of 15 to 74 years by gender in 2000–2011.**



* The current life table estimates were computed using the Sullivan (1971) method and the model-based estimates with the method of Davis *et al.* (2001). The values for the current year 2011 are preliminary estimates.

12 In its strictest form, *cohort (working-) life table* records the actual experience of a particular group of individuals (the worker cohort) from a specific age to (the final retirement from the labor force or) death. The *current or period (working-) life table* considers the experience of a given population during one short period of time, for example, the resident population of Finland in 2010 (*cf.* Chiang, 1968, Chapter 9).

Yet, these estimates are parallel taking into consideration the fundamental differences in the estimation approaches: *viz.* modeling *versus* tabulation. The two methods differ in that the multistate regression estimates are derived from cohort life table data for rates of change between the states (of being either [un]employed in the labor force or being outside it, or finally leaving the population through death), whereas the current life table estimates do not reflect dynamic changes but instead are computed directly from annual labor force participation rates during the period of sampling. Theoretically, the two methods should give identical results if the populations were stable and age-specific transitions did not alter from year-to-year (Smith 1982). Current life tables formed in a recessionary period, during which labor force exits increase, present a bleak picture of working-life involvement. Conversely, those calculated during a subsequent period of recovery tend to exaggerate labor force attachment (Table 9.2.1).

Uncertainty of the expectancy figures is inherent in any statistical estimation. Debating whether the actual working-life expectancy in a given year and a certain sub-population is exactly 35.5 or 35.2 years, or which method is somewhat less accurate, is missing the essence, unless one wants to look at a ‘snapshot’ rather than a trend to gain a wider perspective. Almost any period chosen for observation provides somewhat inaccurate (biased) working-life expectancies for at least some demographic groups. Nevertheless, the discrepancies between the working-life expectancies estimated using the two different methods are important and large, *e.g.*, for year 2010: 2.0 y for males and 1.5 y for females in excess for the model-based estimates *versus* prevalence.

Working-life expectancy is a period or cohort measure, depending on whether cross-sectional or longitudinal data are available. Usually the latter data are not readily accessible or are prohibitively expensive. Real people age and die as members of cohorts through successive periods subject to ever-changing rates. Period life expectancy is constructed as an entirely synthetic measure, referring to a hypothetical cohort living its whole life according to the rates of a single period. Thus working-life expectancies, defined in this study abstractly through hypothetical cohorts, can be paralleled with the experience of real cohorts, making them easier to interpret.

The major novelty of the applied methodology lies in its way to reconstruct the relevant elements of the longitudinal stochastic process that generated the working-life table datasets from sequential cross-sectional surveys. This was made possible by estimating the marginal probabilities using a weighted least squares procedure under a multistate regression, and this in turn led to estimates of cohort expectancies. This approach is different to the traditional technique (Sullivan 1971) that does not yield a cohort measure from cross-sectional data.

Mathers (2000) noted that "The problems with Sullivan's method arises not because it uses prevalence and mortality data averaged over all health states, but because the data it uses are dependent on past conditions in the population [p 190]". Therefore, the Sullivan method for calculating period expectancy does not produce a 'pure' cross-sectional indicator derived from the current prevalence rates summarizing the experience of a population at a point in time. The period expectancy computed from standard life tables, for example at the age of 25 for Finnish men in 2010, is a pure cross-sectional indicator in the sense that it gives the expectation of remaining employment time for persons who experience at each age of their life the risk of moving outside the workforce observed for that age for Finnish men in 2010.

However, a simulation study indicated that Sullivan's method provides acceptable estimates of the period working-life expectancy if the changes in transition rates over a reasonably long term are smooth and fairly regular (Mathers and Robine 1997). In particular, the repeated application of the method can provide good estimates of trends in health and worklife expectancy. But as Davis *et al.* (2001) pointed out, "*By definition the Sullivan method as described cannot supply these estimates [of cohort expectancies], except in so far that a period measure is a surrogate for the analogous cohort quantity [p 1099].*"

As has been recognized (Goldstein and Wachter 2006; Myrskylä 2010), period and cohort expectancies can be interpreted as a time-delayed ('lagged') measure of the experience of real cohorts in populations undergoing demographic changes such as aging and mortality improvement. We found that the difference ('gap') between period and cohort working-life expectancies at a moment in time rose and shrunk over the last decade. The likely reason for this observable fact is the volatility of market forces.

Empirical evidence of this phenomenon was provided by the prospective follow-up study of an actual cohort of active Finnish municipal workers at three successive surveys (Nurminen et al. 2004a,b). The data were analyzed both as aggregate cross-sectional data for estimating marginal probabilities and as an individually-linked longitudinal time series for the estimation of transition probabilities between four work/heath states. Here the index expectancy state was defined as currently/continued having excellent or good work ability. A comparison of the working-life expectancies gave these estimates for a 45-year-old man up to retirement age of 62.5 years in 1981: 7.3 years (transition probabilities), 5.5 years (marginal probabilities). The gap favored, by 1.8 years, the working-life expectancy based on transition probabilities, calculated conditional on having been in the index state at the preceding time point.

To summarize the differences between the applied regression estimates that simulate the cohort expectancies (Davis *et al.* 2001) and those obtained by the current life table technique (Sullivan 1971) we underscore two points. First, we used estimates of the multistate probabilities based on a parametric model rather than non-parametric working life table estimates which do not take into account the decline in mortality over time. Second, our estimated state occupation times pertain to a particular birth (age) cohort instead of to a particular point in a given period of time (year). We conclude that cohort measures are preferable because they are more relevant to persons living now.

10 Concluding remarks

Extending working-life has become a strategic objective in many industrialized countries facing budgetary concerns at a time of demographic aging. Shorter working lives coupled with increased life expectancy, low fertility and the retirement of the large post-WWII generations both ages and shrinks the economically active share of the population. This will inevitably have major implications for overall economic growth (Skirbekk 2005).

During the past two decades, social policy has been adjusted in Finland in many ways to take better account of the challenges created by population aging and substantial progress has been made in many sectors. Sigg and DeLuigi (2007) assess these measures as a series of comprehensive reforms because they are simultaneously punitive, incentive-rich and long term, and thus make prolonging labor force participation an attractive option. Yet given the size of the challenge, the preparations for the ageing society were assessed still to be insufficient in a report issued by the Prime Minister's Office (2009).

According to the EU-commission (2012), Finland has to accelerate pace in lengthening working careers. Although the Government and the central labour market organizations have already done improvements and the country is on track for balancing the general government finances by 2015, the undertaken measures are still not regarded as sufficient. Demographic projections show that the working age population will decline by over 5 percent from the current labor force over the period 2010–2020. Thus the Commission's recommendation is that it is increasingly important to lengthen working careers. It stresses the need to extend working careers at the beginning, in the middle, and toward the end of the life span. One way of lengthening working careers would be to shorten the traditionally long duration of studies, in particular in higher education (one of the longest in all OECD countries), in order to accelerate graduation and to increase the overall effectiveness of the educational system. The Council further recommended to improve the employability of older workers and their participation in lifelong learning and to consider establishing a link between the statutory retirement age and the life expectancy.

According to the results from this study, the life expectancy of Finnish men grew in 2000–2010 by 2.6 years and by 2.2 years for women. The respective increases in working-life expectancies during the same period were 1.2 years for men and as much as 2.8 years for women. Concurrently, during the past ten years the economically inactive time has decreased significantly, among men 0.9 years and among women 1.9 years. Contrasted with the results from the 1980s and 1990s development, the division of time spent in and out of work has changed direction and started to develop toward a favorable direction from the point of view of solving the sustainability gap.

Appendices

Appendix A: Details of modeling and estimation methods

The details are extracted from the method application in Nurminen *et al*. (2005). For full explication of the stochastic modeling and inference, see Davis (2003).[13]

An important contribution to estimating work life expectancy was made in a methodological paper in the United States by Millimet *et al*. (2003), which resembles the present study in many respects. In the US study, Bureau of Labor Statistics work life tables were subdivided simultaneously by a host of factors such as gender, race, and education, not only by a singular characteristic at a time. Pooling together multiple years of data, rather than using a single wave of the Current Population Survey, ensured that the estimates of working-life expectancy are not sensitive to the particular economic conditions that existed the year the data were collected. The data-analytic approach was to apply an econometric model, instead of a simple relative frequency calculation. The modeling strategy allows one to draw greatly more information about persons' working-life behavior and also permits much more detailed working-life expectancy tables to be constructed. Their model, like ours, explicitly incorporated three labor force states: employed, unemployed and inactive (out of the labor force). However, Millimet *et al*. estimated their multinomial model on three subsets of data for the working-life states. We also use a logistic transform to estimate probabilities, but the estimation of the multistate model parameters is done for the three states together by weighted least squares for a large-sample form of vector regression equation. The US study was the first one to recognize explicitly the fact that because working-life tables are generated from survey data, sample variation may be significant.

The major difference and the novelty of the method of Davis *et al.* (2001), compared to the method of Millimet *at al.* (2003), is that it first proves the asymptotic normality of the empirical log-odds. The next step is the estimation of the parameterized true log-odds by way of generalized estimation equations. It is only possible to proceed in this way because the method deals with a large number

13 A *stochastic process* is a family of random variables describing an empirical course whose development is ruled by a probabilistic model. Unlike a deterministic process which can only evolve in one way, a stochastic process involves the vagaries of chance. Even if the initial state of a multistate life table is known (*e.g.* state of being employed), there are several directions in a multinomial distribution in which the stochastic process may progress (remain employed, become unemployed or disabled, retire permanently or die).

of individuals. Millimet *et al*. do not exploit the large number of individuals and they use a standard package for maximizing the likelihood function. In a sense, the method of Davis *et al*. (2001) is not logistic regression since it ends up with weighted least squares as opposed to solving non-linear likelihood equations by Newton-Raphson or some other numerical devise. That is why Davis *et al*. refer to their approach as a large-sample version of multiple regression.

Here our interest is on estimating the marginal probabilities and working-life expectancies that are not conditional on the initial state, but only on the initial age x and gender. For j = 1,2,3,4 and $14 < x < 65$, let $\tilde{l}_j(x)$ be the random variable denoting the number of lives in state j at age x, and let the vector of the frequencies be $\tilde{l}(x) = (\tilde{l}_1(x), \tilde{l}_2(x), \tilde{l}_3(x), \tilde{l}_4(x))'$. We make the assumption of homogeneity in the sense that individuals in the same cohort independently follow the same probabilistic model.

Then define the expectations $l_j(x) = E[\tilde{l}_j(x)]$, $l(x) = E[\tilde{l}(x)]$, j = 1,2,3,4, and assume (Davis *et al*. 2001):

A1. The expectations $l_j(x) = np_j(x)$, where n is the number of lives in a hypothetical cohort.

A2. As n tends to infinity, $n^{-1/2}\{\tilde{l}(x) - l(x)\}$ is asymptotically normally distributed with zero mean and covariance matrix of rank 3:

$$V(x) = \begin{pmatrix} p_1^{-1} + p_4^{-1} & p_4^{-1} & p_4^{-1} \\ p_4^{-1} & p_2^{-1} + p_4^{-1} & p_4^{-1} \\ p_4^{-1} & p_4^{-1} & p_3^{-1} + p_4^{-1} \end{pmatrix},$$

where $p_j \equiv p_j(x)$.

A3. Birth cohorts are stochastically independent, and for each age x the random vector $\tilde{l}(x)$, for large n, follows approximately a multinomial distribution with parameters n and $p_j(x)$.

These assumptions are plausible in a wide variety of circumstances involving the collection of official statistics and can clearly be rephrased to cover, for instance, the case when the number of states is reduced from four to three. The requirement in A2 that the rank of the covariance matrix is one less the number of states is due to the fact that the partition of the four states is exhaustive and $\Sigma_{j=1}^{4} \tilde{l}_j(x) = n$ for all x. The covariance matrix is left general at this stage since a version of the asymptotic normality given below continues to hold when the multinomial requirement of A3 is not true. In particular, our argument can be modified to accommodate the case of a covariance matrix or other features reflecting the sampling scheme.

For the present purposes, failure of the multinomial assumption in A3 results in an incorrect weight matrix in the weighted least squares estimation described below, leading to inefficient but still consistent estimators.

With state 4 (dead), as the reference and form the partial log odds, that is, the ratio of the probability of being in state j at a given age x relative to state 4:

$$\xi_j(x) = \log\{p_j(x)/p_4(x)\} = \log\{l_j(x)/l_4(x)\}, j = 1,2,3, \qquad \text{(Eq A.1)}$$

which are estimated consistently by $\tilde{\xi}_j(x) = \log\{\tilde{l}_j(x)/\tilde{l}_4(x)\}$.

Note that the results of inference for the probabilities are unaffected by the choice of the reference state. The reason for this is that the functional relation between the vectors of log odds with respect to two different reference states is an invertible linear transform (Davis 2003, p. 7–8).

Owing to the one-to-one correspondence between the marginal probabilities for all the states of the stochastic process at a given age x and all the marginal log odds, enables one to estimate the $p_j(x)$ through the use of regression estimates for the $\xi_j(x)$ (*ibid*., Chapter 4).

Exploratory analysis can be used to suggest a parametric form for the log ratios, $\xi(x) \equiv \xi(x;\beta)$, and the estimation of β is done by weighted least squares. With $\hat{\beta}$ the resulting estimate of β we have the estimates:

$$\begin{aligned} &\hat{\xi}(x) = \xi(\mathrm{x};\hat{\beta}), \\ &\hat{p}_4(x) = \{1 + \Sigma_{j=1}^{3} \exp[\hat{\beta}(x)]\}^{-1}, \qquad \text{(Eq A.2)} \\ &\hat{p}_j(x) = \hat{p}_4(x)\exp[\hat{\xi}_{\mathrm{j}}(x)], j = 1,2,3, \end{aligned}$$

Thence the estimated working-life and related expectancies (for given age z) are

$$\hat{e}_j(x) = \hat{p}_j(x) / 2 + \int_{z+1}^{64} \hat{p}_j(x / z)dx, j = 1,2,3,4, \qquad \text{(Eq A.3)}$$

where the maximum age of retirement or exit is assumed to be 64 (or 74) years. These integrals can be evaluated using a discrete approximation but we applied the S-Plus function INTEG.SPLINE (Venables and Ripley 2002), which integrates under a spline function through a set of points.

If the vector of log ratios is modeled by $\xi(t,x) \equiv \xi(t,x;\beta) = Z(t,x)'\beta$, with $Z(t,x)$ an appropriately chosen design matrix, then the *loss function*[14] to be minimized with respect to β is

$$L(\beta) = \sum_{t=2000}^{2010} \sum_{x=15}^{64} \{\hat{\xi}(t,x) - \xi(t,x)\}' V(t,x)^{-1} \{\hat{\xi}(t,x) - \xi(t,x)\}, \qquad \text{(Eq A.4)}$$

where V is the variance-covariance matrix of a multinomial distribution with probabilities p_j, $j = 1,2,3,4$.

Due to dependence along age cohorts, that is along diagonals of the (t,x) plane with $c = t–x$ constant, the variance-covariance matrix of $\hat{\beta}$ was calculated by the method of Liang and Zeger (1986). The generalized estimating equations derived by Davis *et al.* (2001) can be solved for the regression coefficients and to obtain standard errors of the estimated probabilities either analytically or by means of Monte Carlo simulation (Appendix B). Since the Liang-Zeger formula is a function of the observed residuals, it will automatically detect any extra-binomial variation in the model fitting. Thus this procedure results in more precise estimates of working-life expectancy rather than assuming that repeated observations are independent. The part of assumption A3 asserting the stochastic independence of age cohorts is important here.

Finally, the estimation of expectancies conditional on having reached an age z greater than 15 can be done as follows. For a fixed year, let

$$\begin{aligned} p_j(x) = p_j(14;x) &= \Pr(\text{Individual is alive \& in state } j \text{ at } x \mid \text{Alive at 14}) \\ &= \Pr(\text{Individual is alive at } z\text{, and alive \& in state } j \text{ at } x \mid \text{Alive at 14}) \\ &= \Pr(\text{Alive at } z \mid \text{Alive at 14}) \cdot \Pr(\text{Alive \& in state } j \text{ at } x \mid \text{Alive at } z) \\ &= \{\textstyle\sum_{j=1}^{3} p_j(14;z)\}\, p_j(z;x). \end{aligned}$$

Hence the expectancy (up to age 64) of state j for a person of initial age z is

$$e_j(z) = \int_z^{64} p_j(z,x)\mathrm{d}x = \{\textstyle\sum_{j=1}^{3} p_j(z)\}^{-1} \int_z^{64} p_j(x)\mathrm{d}x. \qquad \text{(Eq A.5)}$$

This is estimated consistently by substituting the $\hat{p}_j(x)$ of Eq A.2.

14 In statistics, *loss function* is a function that maps an event onto a real number intuitively representing some 'cost' associated with the event. In this instance, it is used for the estimation of the vector parameter (β), and the event in question is a function of the difference between estimated ($\hat{\xi}$) and true (ξ) log-ratios of the data (t,x) weighted by the covariance matrix V (see Eq A.4). The 'cost' is the inefficiency of the estimate.

The second-order moments of the probabilities can be estimated using the delta method. That is, the covariance matrix of $\hat{p}_j(x)$ is obtained from the following expression:

$$\mathrm{Var}(\hat{p}_j(x)) = \{\partial\hat{p}_j(x)/\partial\beta^{\mathrm{T}}\}\ \mathrm{Cov}(\hat{\beta})\ \{\partial\hat{p}_j(x)^{\mathrm{T}}/\partial\beta\} \qquad \text{(Eq A.6)}$$

The partial derivatives of the probabilities with respect to β can be easily found.

Let $\xi_j(t,x) = \log\{p_j(t,x)/p_4(t,x)\}, j = 1,2,3$. After some experimentation the male models chosen were linear, quadratic or cubic in age x, linear in year t, with cross-product terms. In addition, the model included the *GDP* and its modification by the prevalence of unemployment (Prev), the standard indicator function $I(\cdot)$ for the years of the new pension legislation from 2005 onwards, the unemployment pension 'tunnel', as well as for the teen ages (15 to 19 years) and the senior ages (60+ years).

Explicitly, the state-specific models selected for the male log ratios assumed the following form:

$$\begin{aligned}
\xi_1(t,x) &= \beta_1 + \beta_2 x + \beta_3 x^2 + \beta_4 I(15{\le}x{\le}19) + \beta_5{\cdot}I(x{\ge}60) \\
&\quad + \beta_6 t + \beta_7 I(55/57{\le}x{\le}64) + \beta_8{\cdot}GDP \\
\xi_2(t,x) &= \beta_9 + \beta_{10} x + \beta_{11} x^2 + \beta_{12} x^3 + \beta_{13} I(15{\le}x{\le}19) + \beta_{14} I(x{\ge}60) \\
&\quad + \beta_{15} t + \beta_{16} tx + \beta_{17} tx^2 + \beta_{18} + I(2005{\le}t{\le}2010) \\
&\quad + \beta_{19} I(55/57{\le}x{\le}64) + \beta_{20} GDP * Prev \\
\xi_3(t,x) &= \beta_{21} + \beta_{22} x + \beta_{23} x^2 + \beta_{24} x^3 + \beta_{25} I(x \ge 60) + \beta_{26} t + \beta_{27} tx \\
&\quad + \beta_{28} tx^2 + \beta_{29} I(2005 \le t \le 2010) + \beta_{30} I(55/57{\le}x{\le}64)
\end{aligned} \qquad \text{(EA.7)}$$

The models selected for the female log ratios are rather similar and are as follows:

$$\begin{aligned}
\xi_1(t,x) &= \beta_1 + \beta_2 x + \beta_3 x^2 + \beta_4 I(15{\le}x{\le}19) + \beta_5 I(x{\ge}60) + \beta_6 t + \beta_7 tx \\
&\quad + \beta_8 tx^2 + \beta_9 I(55/57{\le}x{\le}64) \\
\xi_2(t,x) &= \beta_{10} + \beta_{11} x + \beta_{12} x^2 + \beta_{13} I(15{\le}x{\le}19) + \beta_{14} I(x{\ge}60) + \beta_{15} t \\
&\quad + \beta_{16} tx + \beta_{17} tx^2 + \beta_{18} I(55/57{\le}x{\le}64) \\
\xi_3(t,x) &= \beta_{19} + \beta_{20}\mathrm{x} + \beta_{21}\mathrm{x}^2 + \beta_{22}\,\mathrm{x}^3 + \beta_{23} I(x{\ge}60) + \beta_{24} t + \beta_{25} I(55/57{\le}x{\le}64)
\end{aligned} \qquad \text{(Eq A.8)}$$

Estimates of the coefficients of the regression model parameters and their standard errors are given in Table 5.1 for males and Table 5.2 for females.

Large-sample significance tests of the probabilities can easily be constructed. To take a particular case, consider the difference between males and females in the probability of employment in the economic recession year 2009. The gender difference for an 'average' (or randomly chosen) 25-year old male worker (Table C.1) was greater than that for women (Table C.2):

$$\hat{p}_1^{M,\,2009}(25) - \hat{p}_1^{F,\,2009}(25) = 0.7241 - 0.6428 = 0.0813$$

Assuming that the male and female models are stochastically independent, the standard error of the difference is estimated by computing the variance-covariance matrix for the fitted probabilities (using the Liang-Zeger method of generalized estimating equations):

$$\begin{aligned} \mathrm{SE}\{\hat{p}(25) - \hat{p}(25)\} &= \{\mathrm{SE}[\hat{p}_1^{M,\,2009}(25)]^2 + \mathrm{SE}[\hat{p}_1^{F,\,2009}(25)]^2\}^{1/2} \\ &= (0.006795^2 + 0.008664^2)^{1/2} = 0.0110. \end{aligned}$$

In these large survey datasets, the normal (Gaussian) test realization z = 0.0813/0.0110 = 7.39, which corresponds to a right-tailed P-value < 0.001. Hence, the estimated gender gap in employment probabilities is highly significant. Men typically suffer more from jobs lost in recession.

To exemplify significance testing of a difference between expectancies, we next consider the expectations for a randomly chosen 25-year-old employed male worker which were: $\hat{e}_1^{M,2004}(25) = 29.61$y; $\hat{e}_1^{M,2005}(25) = 30.44$y, *i.e.* +0.83%; and for a female they were: $\hat{e}_1^{F,2004}(25) = 28.43$y, $\hat{e}_1^{F,2005}(25) = 28.18$y, *i.e.* +0.25%. In effect, the indicator term for the pension reform enactment year 2005 divides the calendar year to two separate ranges of 2000–2004 and 2005–2010, and assesses the equality of the slopes of two regression lines in these sub-intervals. Thus, there is reason to test more specifically whether the apparent 1-year shift at 2004/2005 was statistically significant for either gender.

The standard errors of the expectancies are estimated directly by summing the covariance matrix for the fitted probabilities over age from present age to retirement age. Given the rotating sampling scheme, we can assume that the models for the calendar years are approximately independent. For a 25-year-old employed male worker we obtain the Liang-Zeger standard error estimate of $(0.1316^2+0.1291^2)^{1/2} = 0.18$. The standard normal test statistic is $z = 0.83/0.18 = 4.50$, and one may infer that for males of that age in 2005 there was a statistically highly significant rise in the expectancy of employment ($P < 0.001$). Hence, the 95 percent confidence interval for this difference is (0.47, 1.20) years.

For females, the respective difference is 28.43 – 28.18 = 0.25 years, and its standard error estimate is $(0.1086^2 + 0.1157^2)^{½} = 0.16$. The test statistic takes on the value of $z = 0.25/0.16 = 1.58$, which corresponds to an almost significant difference (upper-tail $P = 0.058$). One has to remember though that in these large datasets many subgroup comparisons may turn out to be significant.

Appendix B: The Liang-Zeger estimator

By courtesy of Dr. Brett A. Davis, 17 July 2011.

The Liang-Zeger (1986) method of generalized estimating equations is applied to compute the covariance matrix, $Var\,(\hat{\beta})$, of the regression parameter estimates, $\hat{\beta}$, by using the delta method, that is by minimizing the loss function in Eq A.4.

This class of estimating equations provides an efficient means of incorporating autocorrelation between repeated observations on a subject when estimating the covariance of the regression coefficients thus enabling valid inference. The standard errors of the working-life expectancies can then be obtained directly by summing the covariance matrix of the fitted probabilities over age (from present age to retirement age). Since the Liang-Zeger estimator is a function of the observed residuals, it should automatically detect any extra-binomial variation.

Alternatively, the variance of the working-life expectancy estimates can be obtained by using a Monte Carlo simulation technique. This is done by using replicate parameter estimates $\hat{\beta}^{(i)}$ to generate replicate estimates of the working-life expectancies, $\left(\hat{e}_1^{(i)}, \hat{e}_2^{(i)}, \hat{e}_3^{(i)}\right)$; and the standard error of the $\hat{e}_1^{(i)}s$ is taken as the standard error of the original $\hat{e}_1$ (based on $\hat{\beta}$).

The dataset consists of 50 male cohorts aged 15,...,64 in the year 2000 (Table B.1). For each birth cohort with four polynomial states we perform these 4 steps.

1) Let $\tilde{\theta}_{2000}$ be the observed log odds for the first year 2000. That is,

$$\tilde{\theta}_{2000} = \begin{pmatrix} \log \textit{odds Employed in } 2000 \\ \log \textit{odds Unemployed in } 2000 \\ \log \textit{odds Not in the Labour Force in } 2000 \end{pmatrix}$$

We then construct the 'stacked' column vector of observed log odds

$$\tilde{\theta} = \left(\tilde{\theta}_{2000} \quad \cdots \quad \tilde{\theta}_{2010}\right)^T$$

This column vector has length 33.

2) Construct the corresponding vector of fitted log odds $\hat{\theta} = D\hat{\beta}$, where D is the stacked design matrix with 33 rows and its number of columns is equal to the number of regression parameters. Also calculate the vector of residuals $\varepsilon = \tilde{\theta} - \hat{\theta}$. The product $\varepsilon\varepsilon^T$ is an observed measure of the autocorrelation.

3) Let W_{2000} be the inverse working covariance matrix given by

$$W_{2000} = \begin{pmatrix} \frac{1}{l_4}+\frac{1}{l_1} & \frac{1}{l_4} & \frac{1}{l_4} \\ \frac{1}{l_4} & \frac{1}{l_4}+\frac{1}{l_2} & \frac{1}{l_4} \\ \frac{1}{l_4} & \frac{1}{l_4} & \frac{1}{l_4}+\frac{1}{l_3} \end{pmatrix}^{-1}$$

where the symbols l_1, l_2, l_3, l_4 denote the observed marginal number of lives for this particular year. Matrices $W_{2001,}\ W_{2002}, \cdots, W_{2010}$ are calculated in the same way. We now construct the block diagonal 33 by 33 matrix $W = diag\left(W_{2000} \quad \cdots \quad W_{2010}\right)$.

4) Calculate the products

$$A = D^T W\varepsilon$$
$$B = AA^T$$
$$C = D^T WD$$

The final step is to sum matrices B and C over all 50 cohorts (allowing at least 5 observations per cohort). That is, calculate SB and SC where

$$SB = \sum_{Cohorts} B$$
$$SC = \sum_{Cohorts} C$$

The covariance matrix of the regression parameter estimates is now given by

$$Var\left(\hat{\beta}\right) = \left(SC\right)^{-1} SB \left(SC\right)^{-1}. \qquad \text{(Eq B.1)}$$

Table B.1.

Sampling scheme for the analysis of the multistate working life table. Table gives the numbers of men who were in state j at age x and year t, $l_j(x,t)$, j=1,2,3,4, compiled from the Finnish Labour Force Survey annual files 2000 through 2010. Birth cohort of year 1991 is shown as an example.[15]

Age (y)	2000	2005	2010
15	1996		
16	1995		
17	1994		
18	1993		
19	1992		
20	**1991**	1996	
	l_1 = 14588 l_2 = 5046 l_3 = 14496 l_4 = 44 All = 34174		
21		1995	
22		1994	
23		1993	
24		1992	
25	1986	**1991**	1996
		l_1 = 28458 l_2 = 2765 l_3 = 5991 l_4 = 29 All =37243	
26	1985	1990	1995
27	1984	1989	1994
28	1983	1988	1993
29	1982	1987	1992
30	1981	1986	**1991**
			l_1 = 27686 l_2 = 2400 l_3 = 2769 l_4 = 52 All = 32907

—›

15 Data vectors of the form, $L(x,t) = \{l_1(x,t), l_2(x,t), l_3(x,t), l_4(x,t)\}'$, where: $l_1(x,t)$ = number of individuals employed at the time of the 2000 survey; $l_2(x,t)$ = number of individuals unemployed; $l_3(x,t)$ = number of individuals out of the labor force (students, conscripts, persons on disability pension or old-age pension, etc.), $l_4(x,t)$ = number of deceased persons. Data used in the estimation procedure for all eleven survey years were available for persons born in 1947–1996, that is 50 age groups of 15 to 64 years in 2000.

Since the computation procedure requires at least 5 observations per birth cohort along the diagonal of the (x,t)–matrix, the last estimable age group was 60 years. The frequencies of individuals, born in the same year, in the 4 states can be followed down the diagonals of the table, as shown for age 20 (birth cohort of year 1991 in bold face).

Note that the total sizes of the cross-sectional samples vary. This is because the persons drawn into the samples were not individually linked. A cohort is defined as a closed population in the sense of being closed for exit. In this scheme, cohort is taken to mean a sample from a population born in the same year with turnover in membership in a given period of time.

31	1980	1985	1990
32	1979	1984	1989
33	1978	1983	1988
34	1977	1982	1987
35	1976	1981	1986
36	1975	1980	1985
37	1974	1979	1984
38	1973	1978	1983
39	1972	1977	1982
40	1971	1976	1981
41	1970	1975	1980
42	1969	1974	1979
43	1968	1973	1978
44	1967	1972	1977
45	1966	1971	1976
46	1965	1970	1975
47	1964	1969	1974
48	1963	1968	1973
49	1962	1967	1972
50	1961	1966	1971
51	1960	1965	1970
52	1959	1964	1969
53	1958	1963	1968
54	1957	1962	1967
55	1956	1961	1966
56	1955	1960	1965
57	1954	1959	1964
58	1953	1958	1963
59	1952	1957	1962
60	1951	1956	1961
61	1950	1955	1960
62	1949	1954	1959
63	1948	1953	1958
64	1947	1952	1957

Appendix C: Estimates of labour market state probabilities

Table C.1

Fitted male probabilities of the four labor market states 1 = ‘employed’, 2 = ‘unemployed’, 3 = ‘economically inactive’, and 4 = ‘dead’, for ages x = 15–60 and years 2000–2010.

Age	*State*	Men										
x	*j*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15	1	9.84	9.60	9.42	9.27	9.16	9.79	9.66	9.52	9.26	8.88	9.00
	2	7.04	7.41	7.64	7.83	7.90	6.88	6.98	7.11	7.56	8.36	7.80
	3	83.08	82.95	82.90	82.87	82.90	83.30	83.33	83.34	83.15	82.73	83.17
	4	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03
20	1	48.62	47.66	47.00	46.44	46.10	48.43	48.01	47.53	46.44	44.74	45.58
	2	12.04	12.70	13.03	13.27	13.23	11.24	11.28	11.40	12.20	13.76	12.34
	3	39.25	39.55	39.87	40.21	40.58	40.25	40.63	40.99	41.28	41.43	42.01
	4	0.10	0.10	0.09	0.09	0.08	0.09	0.08	0.08	0.07	0.07	0.07
25	1	74.84	74.13	73.64	73.22	72.97	75.18	74.88	74.53	73.71	72.41	73.06
	2	9.12	9.52	9.74	9.90	9.90	8.14	8.18	8.27	8.74	9.61	8.86
	3	15.90	16.21	16.49	16.76	17.01	16.57	16.82	17.09	17.45	17.88	17.98
	4	0.14	0.13	0.13	0.12	0.12	0.12	0.11	0.11	0.11	0.10	0.10
30	1	85.12	84.70	84.42	84.19	84.07	85.79	85.64	85.46	84.97	84.18	84.64
	2	6.82	7.07	7.19	7.29	7.28	5.87	5.90	5.94	6.22	6.74	6.28
	3	7.90	8.08	8.23	8.38	8.51	8.20	8.33	8.47	8.68	8.96	8.97
	4	0.16	0.15	0.15	0.14	0.14	0.14	0.13	0.13	0.12	0.12	0.11
35	1	88.35	88.06	87.89	87.76	87.71	89.21	89.14	89.04	88.72	88.15	88.55
	2	5.85	6.03	6.11	6.17	6.15	4.92	4.92	4.94	5.14	5.52	5.16
	3	5.61	5.72	5.81	5.90	5.97	5.71	5.78	5.86	5.99	6.18	6.15
	4	0.19	0.19	0.18	0.17	0.17	0.16	0.16	0.15	0.15	0.15	0.14
40	1	88.39	88.15	88.03	87.95	87.97	89.47	89.46	89.41	89.14	88.63	89.09
	2	5.68	5.85	5.92	5.96	5.93	4.73	4.71	4.72	4.91	5.29	4.90
	3	5.67	5.75	5.80	5.85	5.88	5.58	5.62	5.66	5.75	5.89	5.83
	4	0.25	0.25	0.24	0.23	0.22	0.22	0.21	0.20	0.20	0.19	0.18
45	1	85.89	85.70	85.64	85.62	85.71	87.40	87.45	87.47	87.23	86.74	87.31
	2	5.96	6.13	6.21	6.25	6.20	4.95	4.94	4.94	5.14	5.55	5.13
	3	7.78	7.81	7.81	7.80	7.77	7.32	7.30	7.29	7.33	7.43	7.29
	4	0.36	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.29	0.29	0.27
50	1	79.78	79.70	79.78	79.89	80.13	82.23	82.41	82.57	82.42	81.99	82.77
	2	6.20	6.40	6.49	6.55	6.52	5.24	5.24	5.26	5.48	5.91	5.49
	3	13.42	13.32	13.17	13.01	12.82	12.01	11.84	11.68	11.62	11.63	11.30
	4	0.60	0.58	0.56	0.54	0.53	0.52	0.51	0.49	0.48	0.47	0.44
55	1	66.97	67.19	67.59	68.04	68.62	71.46	72.23	72.72	72.85	72.64	73.84
	2	6.87	7.15	7.31	7.44	7.46	6.11	5.07	5.13	5.39	5.87	5.47
	3	25.33	24.85	24.31	23.77	23.18	21.69	21.82	21.30	20.93	20.68	19.91
	4	0.82	0.80	0.78	0.76	0.74	0.75	0.87	0.85	0.83	0.82	0.78
60	1	36.72	37.61	38.64	39.71	40.89	44.03	45.21	46.36	47.22	47.79	49.55
	2	2.27	2.39	2.50	2.61	2.71	2.30	2.38	2.48	2.61	2.78	2.80
	3	59.81	58.81	57.68	56.50	55.24	52.46	51.20	49.97	48.99	48.25	46.50
	4	1.19	1.19	1.18	1.17	1.16	1.21	1.20	1.19	1.18	1.18	1.15

Table C.2

Fitted female probabilities of the four labor market states 1 = 'employed', 2 = 'unemployed', 3 = 'economically inactive', and 4 = 'dead', for ages x = 15–60 and years 2000–2010.

Age	*State*	Women										
x	*j*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15	1	19.75	19.92	20.41	20.90	21.41	21.92	22.44	22.97	23.51	24.05	24.61
	2	9.46	10.74	10.63	10.51	10.40	10.28	10.17	10.05	9.94	9.82	9.71
	3	70.77	69.31	68.94	68.56	68.17	67.77	67.37	66.95	66.53	66.10	65.66
	4	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
20	1	48.56	48.41	48.87	49.32	49.77	50.22	50.67	51.12	51.56	52.01	52.45
	2	9.78	10.62	10.33	10.06	9.79	9.52	9.26	9.01	8.76	8.52	8.29
	3	41.64	40.95	40.77	40.60	40.41	40.23	40.04	39.84	39.65	39.44	39.24
	4	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
25	1	62.48	62.23	62.51	62.78	63.04	63.30	63.55	63.80	64.04	64.28	64.51
	2	9.05	9.50	9.19	8.88	8.59	8.30	8.02	7.75	7.49	7.24	6.99
	3	28.44	28.24	28.27	28.31	28.34	28.37	28.39	28.41	28.43	28.45	28.46
	4	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04
30	1	72.76	72.61	72.82	73.01	73.21	73.39	73.56	73.73	64.04	74.04	74.19
	2	8.17	8.31	8.01	7.72	7.44	7.17	6.91	6.65	7.49	6.17	5.94
	3	19.03	19.03	19.13	19.22	19.31	19.40	19.48	19.57	28.43	19.73	19.81
	4	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.04	0.05	0.05
35	1	79.02	79.07	79.28	79.49	79.68	79.87	80.05	80.22	80.39	80.54	80.70
	2	7.40	7.31	7.04	6.77	6.51	6.26	6.03	5.80	5.57	5.36	5.15
	3	13.52	13.56	13.62	13.68	13.74	13.80	13.86	13.92	13.97	14.03	14.08
	4	0.06	0.06	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07
40	1	82.01	82.30	82.56	82.81	83.05	83.28	83.51	80.22	83.95	84.15	84.35
	2	6.91	6.62	6.36	6.12	5.88	5.65	5.43	5.80	5.02	4.82	4.63
	3	10.99	10.99	10.99	10.98	10.98	10.97	10.96	13.92	10.94	10.93	10.92
	4	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.07	0.10	0.10	0.10
45	1	82.46	82.82	83.17	83.51	83.84	84.17	84.49	84.80	85.10	85.39	85.68
	2	6.49	6.24	6.00	5.77	5.54	5.33	5.12	4.92	4.72	4.53	4.36
	3	10.90	10.79	10.69	10.58	10.47	10.36	10.25	10.15	10.04	9.93	9.82
	4	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
50	1	79.66	80.21	80.76	81.29	81.81	82.32	82.82	83.30	83.78	84.24	84.69
	2	6.34	6.10	5.87	5.65	5.44	5.23	5.03	4.84	4.65	4.47	4.30
	3	13.75	13.44	13.12	12.81	12.51	12.21	11.92	11.63	11.35	11.07	10.79
	4	0.25	0.25	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.22	0.22
55	1	67.16	68.26	69.34	70.40	71.44	72.46	76.87	77.76	78.61	79.45	80.26
	2	6.98	6.77	6.57	6.37	6.17	5.98	5.05	4.88	4.71	4.55	4.39
	3	25.49	24.60	23.73	22.88	22.04	21.23	17.69	16.99	16.31	15.65	15.01
	4	0.38	0.37	0.36	0.35	0.34	0.33	0.39	0.38	0.37	0.36	0.34
60	1	31.31	33.00	34.74	36.51	38.33	40.17	42.05	43.94	45.85	47.78	49.71
	2	1.96	1.97	1.98	1.99	1.99	1.99	1.99	1.98	1.97	1.96	1.95
	3	66.08	64.39	62.65	60.88	59.08	57.25	55.39	53.51	51.63	49.73	47.83
	4	0.65	0.64	0.63	0.61	0.60	0.59	0.58	0.56	0.55	0.53	0.52

Appendix D: Estimates of partial life expectancies

Table D.1

Components of partial life expectancy for Finnish men, expressed in years, of the three states 1 = 'employed', 2 = 'unemployed', and 3 = 'economically inactive', for ages 15–60 at quinquennial intervals, and for the successive years 2000–2010.

Age	State	Men										
x	*j*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15	1	33.4	33.4	33.4	33.4	33.5	34.5	34.5	34.6	34.5	34.2	34.6
	2	3.3	3.5	3.5	3.5	3.5	2.9	2.9	2.9	3.1	3.4	3.1
	3	12.6	12.6	12.5	12.4	12.4	12.0	11.9	11.8	11.8	11.8	11.7
20	1	32.5	32.4	32.4	32.4	32.5	33.5	33.6	33.6	33.5	33.3	33.7
	2	2.8	3.0	3.0	3.1	3.1	2.5	2.5	2.5	2.6	2.9	2.7
	3	9.0	9.0	8.9	8.9	8.8	8.4	8.3	8.2	8.2	8.2	8.0
25	1	29.4	29.4	29.5	29.5	29.6	30.4	30.5	30.6	30.6	30.4	30.8
	2	2.3	2.4	2.4	2.5	2.5	2.0	2.0	2.0	2.1	2.3	2.1
	3	7.6	7.6	7.5	7.4	7.3	6.9	6.8	6.7	6.7	6.7	6.5
30	1	25.4	25.4	25.5	25.6	25.7	26.4	26.5	26.6	26.6	26.5	26.8
	2	1.9	2.0	2.0	2.0	2.0	1.6	1.6	1.6	1.7	1.8	1.7
	3	7.0	7.0	6.9	6.8	6.7	6.3	6.2	6.1	6.0	6.0	5.8
35	1	21.1	21.1	21.2	21.3	21.4	22.1	22.2	22.3	22.3	22.2	22.5
	2	1.6	1.6	1.7	1.7	1.7	1.4	1.4	1.4	1.4	1.5	1.4
	3	6.7	6.6	6.5	6.4	6.3	6.0	5.9	5.8	5.7	5.6	5.4
40	1	16.7	16.7	16.8	16.9	17.0	17.6	17.7	17.8	17.8	17.8	18.1
	2	1.3	1.3	1.4	1.4	1.4	1.1	1.1	1.1	1.2	1.3	1.2
	3	6.4	6.4	6.2	6.1	6.0	5.7	5.6	5.5	5.4	5.3	5.2
45	1	12.3	12.3	12.4	12.5	12.6	13.1	13.3	13.4	13.4	13.4	13.6
	2	1.0	1.0	1.1	1.1	1.1	0.9	0.9	0.9	0.9	1.0	0.9
	3	6.1	6.0	5.9	5.8	5.7	5.4	5.3	5.2	5.1	5.0	4.8
50	1	8.1	8.2	8.2	8.3	8.5	8.9	9.0	9.1	9.1	9.1	9.3
	2	0.7	0.7	0.7	0.8	0.8	0.6	0.6	0.6	0.7	0.7	0.7
	3	5.7	5.6	5.5	5.3	5.2	5.0	4.9	4.7	4.6	4.6	4.4
55	1	4.3	4.4	4.5	4.6	4.7	5.0	5.1	5.1	5.2	5.2	5.4
	2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	3	4.7	4.7	4.6	4.5	4.4	4.1	4.1	4.0	3.9	3.8	3.7
60	1	1.3	1.4	1.4	1.5	1.5	1.7	1.7	1.8	1.8	1.8	1.9
	2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	3	3.1	3.1	3.0	3.0	2.9	2.8	2.7	2.6	2.6	2.5	2.5

Table D.2

Components the partial life expectancy for Finnish women, expressed in years, of the three states 1 = 'employed, 2 = 'unemployed', and 3 = 'economically inactive', for ages 15–60 at quinquennial intervals, and for the successive years 2000–2010.

Age	*State*	Women										
x	*j*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15	1	31.2	31.4	31.7	31.9	32.2	32.5	32.9	33.2	33.4	33.7	34.0
	2	3.5	3.6	3.5	3.4	3.3	3.2	3.0	3.0	2.9	2.8	2.7
	3	14.7	14.5	14.3	14.1	13.9	13.8	13.5	13.3	13.2	13.0	12.8
20	1	29.9	30.1	30.4	30.7	30.9	31.2	31.5	31.8	32.0	32.3	32.5
	2	3.0	3.0	2.9	2.8	2.7	2.6	2.5	2.5	2.4	2.3	2.2
	3	11.4	11.2	11.1	10.9	10.7	10.6	10.3	10.2	10.0	9.8	9.7
25	1	27.2	27.4	27.7	27.9	28.2	28.4	28.7	29.0	29.2	29.4	29.7
	2	2.6	2.5	2.4	2.4	2.3	2.2	2.1	2.0	2.0	1.9	1.8
	3	9.6	9.4	9.3	9.1	9.0	8.8	8.6	8.4	8.3	8.1	7.9
30	1	23.9	24.1	24.4	24.6	24.8	25.1	25.4	25.6	25.8	26.0	26.3
	2	2.1	2.1	2.0	1.9	1.9	1.8	1.7	1.7	1.6	1.6	1.5
	3	8.4	8.2	8.1	7.9	7.8	7.6	7.3	7.2	7.0	6.8	6.7
35	1	20.1	20.3	20.6	20.8	21.0	21.2	21.5	21.8	22.0	22.2	22.4
	2	1.7	1.7	1.6	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.2
	3	7.6	7.4	7.3	7.1	6.9	6.7	6.5	6.3	6.2	6.0	5.8
40	1	16.1	16.3	16.5	16.7	16.9	17.2	17.4	17.7	17.9	18.1	18.3
	2	1.4	1.3	1.3	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0
	3	7.0	6.8	6.6	6.5	6.3	6.1	5.9	5.7	5.5	5.4	5.2
45	1	12.0	12.2	12.4	12.6	12.8	13.0	13.3	13.4	13.7	13.8	14.0
	2	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8
	3	6.4	6.3	6.1	5.9	5.8	5.6	5.4	5.2	5.0	4.8	4.7
50	1	7.9	8.1	8.3	8.4	8.6	8.8	9.1	9.2	9.4	9.6	9.8
	2	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.5
	3	5.8	5.7	5.5	5.4	5.2	5.0	4.8	4.7	4.5	4.3	4.2
55	1	4.1	4.2	4.4	4.5	4.7	4.8	5.0	5.2	5.3	5.5	5.6
	2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
	3	5.0	4.8	4.7	4.6	4.4	4.3	4.1	4.0	3.8	3.7	3.5
60	1	1.0	1.1	1.2	1.3	1.3	1.4	1.5	1.6	1.7	1.8	1.9
	2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	3	3.4	3.3	3.2	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5

Table D.3

Components of partial life expectancy for men according to three working states, e_1= 'employed', e_2 = 'unemployed', e_3 = 'inactive', in the Finnish workforce, expressed in years, by three levels of educational attainment, primary, secondary, and tertiary, for ages x = 15–60 and years 2000–2010.

Age	State	Men: Primary										
x	*j*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15	1	29.68	29.62	29.62	29.64	29.71	30.16	30.24	30.28	30.18	29.94	30.28
	2	4.54	4.59	4.65	4.71	4.78	4.16	4.20	4.26	4.30	4.33	4.43
	3	15.28	15.30	15.24	15.15	15.01	15.18	15.06	14.96	15.02	15.23	14.79
20	1	28.79	28.73	28.73	28.75	28.81	29.25	29.32	29.36	29.26	29.04	29.35
	2	4.11	4.15	4.20	4.25	4.31	3.76	3.79	3.84	3.88	3.91	3.99
	3	11.60	11.62	11.57	11.50	11.38	11.49	11.39	11.31	11.36	11.55	11.16
25	1	26.16	26.10	26.10	26.12	26.17	26.55	26.61	26.64	26.56	26.36	26.64
	2	3.41	3.46	3.50	3.55	3.59	3.13	3.15	3.19	3.24	3.28	3.32
	3	9.93	9.94	9.90	9.84	9.74	9.82	9.74	9.66	9.71	9.86	9.54
30	1	22.89	22.84	22.84	22.85	22.90	23.21	23.26	23.29	23.21	23.04	23.28
	2	2.72	2.76	2.80	2.84	2.88	2.51	2.53	2.57	2.60	2.64	2.68
	3	8.88	8.90	8.86	8.81	8.72	8.78	8.71	8.64	8.68	8.82	8.54
35	1	19.25	19.20	19.20	19.21	19.25	19.49	19.54	19.56	19.50	19.34	19.56
	2	2.10	2.14	2.18	2.21	2.25	1.96	1.98	2.01	2.04	2.08	2.11
	3	8.15	8.16	8.13	8.08	8.00	8.05	7.99	7.93	7.96	8.08	7.83
40	1	15.39	15.35	15.35	15.36	15.40	15.57	15.62	15.64	15.58	15.45	15.63
	2	1.58	1.61	1.64	1.67	1.70	1.49	1.50	1.53	1.56	1.59	1.63
	3	7.53	7.54	7.51	7.47	7.39	7.44	7.38	7.33	7.36	7.46	7.24
45	1	11.48	11.45	11.45	11.46	11.49	11.61	11.65	11.67	11.62	11.50	11.67
	2	1.13	1.15	1.18	1.21	1.24	1.08	1.09	1.12	1.15	1.17	1.20
	3	6.89	6.90	6.87	6.84	6.77	6.81	6.76	6.71	6.74	6.83	6.63
50	1	7.66	7.63	7.63	7.64	7.67	7.74	7.78	7.80	7.76	7.67	7.80
	2	0.74	0.76	0.78	0.81	0.83	0.73	0.73	0.75	0.78	0.80	0.82
	3	6.10	6.10	6.08	6.05	6.00	6.03	5.98	5.95	5.96	6.04	5.88
55	1	4.18	4.17	4.17	7.64	4.20	4.23	4.26	4.28	4.25	4.19	4.28
	2	0.41	0.42	0.44	0.81	0.48	0.42	0.42	0.43	0.45	0.46	0.48
	3	4.90	4.90	4.89	6.05	4.82	4.85	4.82	4.79	4.80	4.85	4.74
60	1	1.38	1.38	1.38	1.39	1.40	1.40	1.41	1.42	1.41	1.38	1.43
	2	0.09	0.09	0.10	0.10	0.11	0.09	0.10	0.10	0.11	0.11	0.12
	3	3.03	3.03	3.02	3.01	3.00	3.00	2.99	2.97	2.98	3.00	2.95

Age	*State*	**Men: Secondary**										
x	*j*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15	1	33.31	33.21	33.24	33.31	33.49	34.13	34.24	34.35	34.19	33.75	34.45
	2	3.52	3.74	3.84	3.90	3.85	3.07	3.03	3.05	3.31	3.86	3.32
	3	12.67	12.55	12.42	12.29	12.16	12.29	12.23	12.10	12.00	11.89	11.74
20	1	32.12	32.03	32.05	32.11	32.27	32.88	32.97	33.07	32.93	32.52	33.15
	2	3.01	3.19	3.26	3.30	3.25	2.58	2.53	2.53	2.74	3.17	2.72
	3	9.36	9.28	9.19	9.09	8.98	9.04	9.00	8.90	8.84	8.80	8.63
25	1	29.17	29.09	29.12	29.17	29.31	29.83	29.90	29.98	29.88	29.57	30.07
	2	2.50	2.63	2.68	2.70	2.67	2.10	2.05	2.06	2.20	2.51	2.18
	3	7.83	7.78	7.70	7.62	7.53	7.57	7.55	7.46	7.42	7.42	7.25
30	1	25.32	25.27	25.29	25.34	25.45	25.90	25.95	26.03	25.94	25.70	26.11
	2	2.12	2.22	2.26	2.28	2.25	1.77	1.73	1.73	1.85	2.09	1.83
	3	7.06	7.01	6.95	6.88	6.80	6.83	6.82	6.74	6.71	6.71	6.56
35	1	21.10	21.05	21.07	21.12	21.22	21.59	21.64	21.70	21.63	21.43	21.78
	2	1.80	1.88	1.92	1.94	1.92	1.51	1.47	1.47	1.57	1.77	1.56
	3	6.61	6.57	6.51	6.44	6.37	6.40	6.40	6.33	6.30	6.30	6.16
40	1	16.75	16.71	16.73	16.78	16.86	17.17	17.21	17.26	17.21	17.03	17.34
	2	1.49	1.56	1.59	1.61	1.60	1.26	1.22	1.23	1.31	1.48	1.31
	3	6.27	6.23	6.17	6.11	6.04	6.07	6.07	6.01	5.98	5.98	5.85
45	1	12.43	12.40	12.42	12.46	12.53	12.77	12.79	12.85	12.80	12.66	12.92
	2	1.16	1.22	1.25	1.27	1.26	0.99	0.96	0.97	1.04	1.17	1.04
	3	5.91	5.88	5.83	5.77	5.71	5.74	5.74	5.69	5.66	5.66	5.54
50	1	8.27	8.25	8.27	8.30	8.36	8.52	8.54	8.58	8.55	8.45	8.65
	2	0.81	0.85	0.87	0.89	0.89	0.70	0.67	0.68	0.73	0.83	0.74
	3	5.43	5.40	5.35	5.30	5.25	5.27	5.29	5.24	5.22	5.22	5.11
55	1	4.49	4.49	4.50	4.53	4.57	8.52	4.65	4.68	4.67	4.61	4.74
	2	0.45	0.48	0.50	0.51	0.51	0.70	0.39	0.39	0.42	0.48	0.42
	3	4.56	4.53	4.50	4.46	4.42	5.27	4.48	4.44	4.42	4.42	4.34
60	1	1.46	1.46	1.47	1.49	1.51	1.53	1.54	1.56	1.56	1.55	1.59
	2	0.11	0.11	0.12	0.12	0.13	0.10	0.10	0.11	0.11	0.12	0.12
	3	2.93	2.92	2.91	2.89	2.87	2.87	2.85	2.83	2.83	2.83	2.79

Age	*State*	Men: Tertiary										
x	*j*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15	1	37.05	37.10	37.16	37.21	37.27	37.76	37.81	37.86	37.87	37.84	37.93
	2	2.38	2.50	2.65	2.81	3.01	2.56	2.71	2.90	3.03	3.11	3.47
	3	10.06	9.90	9.70	9.48	9.22	9.18	8.98	8.74	8.60	8.54	8.10
20	1	36.86	36.90	36.95	37.00	37.05	37.53	37.58	37.62	37.62	37.60	37.67
	2	2.05	2.13	2.23	2.34	2.47	2.07	2.16	2.28	2.36	2.41	2.62
	3	5.60	5.48	5.32	5.16	4.97	4.90	4.76	4.60	4.52	4.49	4.21
25	1	33.19	33.24	33.30	33.38	33.46	33.83	33.90	33.97	33.99	33.98	34.12
	2	1.45	1.50	1.55	1.61	1.68	1.39	1.42	1.48	1.52	1.56	1.65
	3	4.86	4.77	4.64	4.51	4.36	4.28	4.18	4.05	3.98	3.97	3.73
30	1	28.78	28.84	28.91	28.99	29.07	29.39	29.47	29.55	29.58	29.57	29.72
	2	1.20	1.23	1.27	1.31	1.36	1.11	1.12	1.16	1.19	1.22	1.28
	3	4.52	4.43	4.32	4.20	4.07	4.00	3.91	3.79	3.73	3.71	3.50
35	1	24.14	24.19	24.27	24.35	24.44	24.72	24.79	24.87	24.91	24.91	25.06
	2	1.04	1.07	1.10	1.13	1.17	0.95	0.96	0.98	1.01	1.02	1.07
	3	4.32	4.24	4.13	4.02	3.90	3.83	3.75	3.64	3.58	3.57	3.37
40	1	19.43	19.48	19.56	19.64	19.73	19.97	20.05	20.13	20.17	20.18	20.33
	2	0.91	0.93	0.95	0.98	1.01	0.82	0.82	0.84	0.86	0.87	0.91
	3	4.17	4.09	3.99	3.89	3.77	3.71	3.63	3.53	3.47	3.46	3.26
45	1	14.74	14.79	14.87	14.94	15.03	15.25	15.32	15.40	15.45	15.45	15.60
	2	0.75	0.77	0.79	0.81	0.83	0.68	0.67	0.69	0.70	0.71	0.74
	3	4.01	3.94	3.85	3.75	3.63	3.58	3.51	3.41	3.35	3.34	3.16
50	1	10.15	10.20	10.27	10.35	10.43	10.60	10.67	10.75	10.79	10.80	10.95
	2	0.57	0.58	0.60	0.61	0.63	0.51	0.50	0.51	0.52	0.53	0.55
	3	3.78	3.72	3.63	3.54	3.44	3.39	3.33	3.23	3.18	3.17	3.00
55	1	5.80	5.84	5.90	5.97	6.04	6.16	6.22	6.29	6.33	6.33	6.46
	2	0.36	0.37	0.38	0.39	0.40	0.33	0.31	0.32	0.31	0.32	0.33
	3	3.35	3.29	3.22	3.15	3.06	3.02	2.98	2.90	2.86	2.85	2.70
60	1	1.99	2.02	2.06	2.10	2.15	2.20	2.24	2.29	2.31	2.32	2.40
	2	0.08	0.09	0.09	0.09	0.10	0.08	0.08	0.08	0.09	0.09	0.09
	3	2.43	2.40	2.35	2.31	2.25	2.23	2.18	2.13	2.10	2.09	2.00

Table D.4

Components of partial life expectancy for women according to three working states, e_1= 'employed', e_2 = 'unemployed', e_3 = 'inactive', in the Finnish workforce, expressed in years, by three levels of educational attainment, primary, secondary, and tertiary, for ages x = 15–60 and years 2000–2010.

Age	*State*	Women: Primary										
x	*j*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15	1	26.23	26.18	26.16	26.13	26.11	26.08	26.18	26.15	26.12	26.10	26.07
	2	4.79	4.81	4.76	4.71	4.66	4.61	4.53	4.48	4.43	4.38	4.33
	3	18.47	18.51	18.58	18.66	18.73	18.81	18.80	18.87	18.95	19.02	19.10
20	1	25.22	25.16	25.13	25.09	25.05	25.02	25.10	25.06	25.02	24.98	24.94
	2	4.29	4.29	4.25	4.21	4.16	4.12	4.05	4.01	3.96	3.92	3.88
	3	14.99	15.05	15.13	15.21	15.28	15.36	15.36	15.44	15.52	15.60	15.68
25	1	23.40	23.36	23.33	23.30	23.28	23.25	23.34	23.31	23.29	23.26	23.23
	2	3.73	3.72	3.69	3.65	3.62	3.59	3.52	3.49	3.45	3.42	3.38
	3	12.38	12.43	12.49	12.54	12.60	12.67	12.64	12.70	12.76	12.83	12.89
30	1	17.59	20.76	23.33	20.77	20.77	20.77	20.89	20.89	20.90	20.90	20.90
	2	2.47	3.08	3.69	3.02	2.99	2.97	2.91	2.88	2.85	2.83	2.80
	3	9.44	10.66	12.49	10.71	10.74	10.76	10.70	10.73	10.75	10.78	10.81
35	1	14.10	17.62	17.66	17.70	17.73	17.77	17.93	17.97	18.01	18.04	18.08
	2	1.89	2.45	2.42	2.40	2.37	2.35	2.29	2.27	2.24	2.22	2.19
	3	8.51	9.43	9.42	9.41	9.40	9.38	9.28	9.27	9.25	9.24	9.23
40	1	10.47	14.16	17.66	14.30	14.37	14.44	14.63	14.70	14.78	14.85	14.93
	2	1.37	1.87	2.42	1.82	1.79	1.77	1.72	1.69	1.67	1.65	1.62
	3	7.66	8.47	9.42	8.38	8.34	8.29	8.15	8.10	8.05	8.00	7.95
45	1	6.87	10.56	10.65	10.74	10.84	10.94	11.15	11.25	11.35	11.45	11.56
	2	0.91	1.35	1.33	1.30	1.28	1.26	1.21	1.18	1.16	1.14	1.12
	3	6.72	7.59	7.52	7.45	7.38	7.31	7.14	7.06	6.99	6.90	6.82
50	1	3.53	6.97	7.07	7.18	7.28	7.39	7.62	7.73	7.85	7.96	8.08
	2	0.51	0.89	0.87	0.85	0.84	0.82	0.77	0.75	0.74	0.72	0.70
	3	5.45	6.64	6.56	6.47	6.38	6.29	6.11	6.01	5.92	5.82	5.72
55	1	3.53	3.62	3.72	3.82	3.92	4.02	4.20	4.30	4.41	4.52	4.63
	2	0.51	0.50	0.49	0.47	0.46	0.45	0.42	0.41	0.40	0.39	0.38
	3	5.45	5.37	5.29	5.20	5.11	5.02	4.89	4.80	4.70	4.61	4.51
60	1	0.87	0.92	0.97	1.03	1.08	1.14	1.20	1.27	1.33	1.40	1.46
	2	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09
	3	3.53	3.48	3.43	3.38	3.32	3.26	3.21	3.14	3.08	3.02	2.95

Age	State	Women: Secondary										
x	*j*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15	1	31.59	31.84	32.15	32.45	32.76	33.07	33.60	33.90	34.20	34.49	34.78
	2	4.04	4.03	3.92	3.82	3.71	3.62	3.51	3.42	3.33	3.24	3.15
	3	13.88	13.64	13.43	13.23	13.03	12.82	12.38	12.18	11.98	11.78	11.57
20	1	29.39	29.60	29.85	30.10	30.35	30.59	31.07	31.31	31.54	31.78	32.01
	2	3.36	3.31	3.20	3.11	3.01	2.92	2.82	2.73	2.65	2.56	2.48
	3	11.76	11.59	11.44	11.29	11.14	10.99	10.61	10.46	10.31	10.16	10.01
25	1	26.75	26.94	27.15	27.36	27.57	27.77	28.21	28.41	28.60	28.80	28.99
	2	2.86	2.79	2.70	2.62	2.53	2.45	2.36	2.29	2.21	2.14	2.07
	3	9.89	9.77	9.65	9.53	9.40	9.28	8.93	8.81	8.68	8.56	8.43
30	1	23.50	23.68	23.87	24.05	24.24	24.42	24.83	25.01	25.19	25.36	25.53
	2	2.37	2.30	2.23	2.16	2.09	2.02	1.95	1.89	1.83	1.77	1.72
	3	8.63	8.51	8.40	8.29	8.17	8.05	7.71	7.60	7.48	7.37	7.25
35	1	19.87	20.04	20.21	20.38	20.55	20.72	21.11	21.28	21.44	21.60	21.76
	2	1.92	1.86	1.80	1.75	1.70	1.64	1.59	1.54	1.49	1.45	1.41
	3	7.72	7.60	7.49	7.37	7.26	7.14	6.80	6.68	6.57	6.45	6.33
40	1	16.01	16.17	16.33	16.49	16.64	16.80	17.19	17.34	17.49	17.65	17.80
	2	1.50	1.45	1.41	1.38	1.34	1.30	1.26	1.23	1.19	1.16	1.13
	3	6.99	6.88	6.76	6.64	6.52	6.40	6.05	5.93	5.81	5.69	5.57
45	1	12.05	12.19	12.34	12.48	12.63	12.78	13.15	13.30	13.44	13.58	13.72
	2	1.11	1.08	1.06	1.03	1.01	0.99	0.96	0.93	0.91	0.89	0.87
	3	6.34	6.23	6.11	5.98	5.86	5.74	5.39	5.27	5.15	5.03	4.91
50	1	8.07	8.20	8.33	8.46	8.59	8.72	9.09	9.22	9.35	9.48	9.61
	2	0.74	0.73	0.72	0.71	0.69	0.68	0.67	0.65	0.64	0.63	0.62
	3	5.68	5.57	5.45	5.33	5.21	5.09	4.75	4.63	4.51	4.39	4.28
55	1	4.25	4.36	4.47	4.58	4.69	4.80	5.10	5.21	5.32	5.43	5.54
	2	0.41	0.41	0.40	0.40	0.40	0.40	0.39	0.39	0.38	0.38	0.38
	3	4.84	4.73	4.63	4.52	4.41	4.31	4.02	3.92	3.81	3.71	3.60
60	1	1.16	1.22	1.28	1.34	1.40	1.47	1.53	1.60	1.67	1.74	1.81
	2	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08
	3	3.28	3.22	3.16	3.09	3.03	2.96	2.89	2.83	2.75	2.68	2.61

Age	State	Women: Tertiary										
x	*j*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15	1	34.69	34.70	34.84	34.98	35.12	35.25	35.53	35.66	35.78	35.91	36.03
	2	2.37	2.53	2.44	2.36	2.28	2.21	2.13	2.06	1.99	1.93	1.87
	3	12.43	12.27	12.22	12.16	12.10	12.04	11.84	11.78	11.72	11.66	11.61
20	1	34.50	34.50	34.63	34.76	34.89	35.02	35.29	35.41	35.53	35.64	35.75
	2	2.13	2.24	2.17	2.10	2.03	1.97	1.91	1.85	1.80	1.75	1.70
	3	7.86	7.76	7.70	7.64	7.57	7.51	7.30	7.24	7.18	7.12	7.06
25	1	31.15	31.18	31.28	31.38	31.47	31.57	31.81	31.90	31.99	32.07	32.16
	2	1.68	1.71	1.68	1.64	1.60	1.57	1.53	1.50	1.46	1.43	1.40
	3	6.68	6.60	6.54	6.48	6.42	6.36	6.16	6.10	6.05	5.99	5.94
30	1	27.30	27.36	27.45	27.54	27.62	27.71	27.94	28.02	28.10	28.18	28.26
	2	1.33	1.33	1.31	1.29	1.27	1.25	1.23	1.21	1.20	1.18	1.16
	3	5.88	5.81	5.74	5.67	5.60	5.54	5.33	5.26	5.20	5.14	5.08
35	1	23.14	23.22	23.31	23.40	23.49	23.57	23.81	23.90	23.98	24.06	24.14
	2	1.05	1.04	1.03	1.02	1.02	1.01	0.99	0.98	0.97	0.96	0.95
	3	5.31	5.23	5.15	5.08	5.00	4.92	4.70	4.62	4.55	4.48	4.41
40	1	18.81	18.90	18.99	19.09	19.18	19.27	19.52	19.61	19.69	19.78	19.87
	2	0.83	0.82	0.81	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.77
	3	4.87	4.78	4.69	4.61	4.52	4.43	4.19	4.11	4.03	3.94	3.86
45	1	14.39	14.48	14.58	14.68	14.77	14.87	15.12	15.22	15.31	15.40	15.50
	2	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61	0.61	0.60	0.60
	3	4.49	4.39	4.30	4.20	4.11	4.01	3.77	3.68	3.59	3.49	3.40
50	1	9.93	10.03	10.13	10.22	10.32	10.42	10.67	10.77	10.87	10.96	11.06
	2	0.45	0.45	0.45	0.45	5.97	0.45	0.44	0.44	0.44	0.44	0.44
	3	4.12	4.03	3.93	3.83	1.87	3.63	3.38	3.29	3.19	3.10	3.01
55	1	5.60	5.69	5.78	5.87	5.97	6.06	6.24	6.33	6.42	6.51	6.60
	2	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
	3	3.63	3.53	3.44	3.35	3.25	3.16	2.99	2.90	2.81	2.72	2.63
60	1	1.60	1.67	1.73	1.80	1.87	1.94	2.02	2.09	2.16	2.23	2.31
	2	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09
	3	2.83	2.76	2.69	2.62	2.55	2.47	2.40	2.33	2.25	2.18	2.11

Appendix E: Forecasting and setting prediction intervals

This Appendix presents approaches to forecasting and to setting prediction intervals. By *prediction interval* we mean an interval that has a prescribed probability of containing the value of a random variable (Alho and Spencer 2005). In contrast, a confidence interval is a random interval with a prescribed probability of including a constant, such as a mean. A prediction interval is based on a standard error (for the predicted probabilities or expectancies) that includes the residual variance (of the regression model for the partial log odds) as well as the variance of the model parameter estimates. Numerical estimates of the predicted future years of employment, with prediction intervals, are given for the years 2011–2015, separately for males in Table E.1 and for females in Table E.2.

Just as future development of life expectancy cannot be predicted without error, we can only assess the possible expected duration of working-life risks probabilistically (Alho 2003). As the development of future labor force movements is unknown, it is of interest to consider the level of uncertainty with which one can forecast the working-life expectancy. Predictive estimates of the duration of working-life can be important in two ways. First, they can be communicated to the working-age population, so that they may help workers to prepare better for their own retirement. Second, predictive estimates of working-life length are needed for the economic analyses of retirement decisions to properly account for the risk aversion of the future retirees.

Prediction intervals for forecasts can be calculated in multiple ways. One way is to use the variance of the residuals and the parameter estimates extracted from the maximum likelihood regression model fit. However, this approach may yield misleading interpretations if we are not aware of the methodological constraints. This is because it is not plausible that we could predict with any certainty how future social, economical and political interventions diverge from the historical rates of change. For example, economic recessions tend to take place at a short notice (say after a fiscal shock) and are by and large unpredictable (Heathcote and Higgins 2001).

Another method to construct prediction intervals would be to estimate the variance for a model developed without indicators or non-linear term, because long-term prediction of exceptional events or irregularities is not possible. For example, we argue that the normal density ordinate that was used to model the disability hump during the economic recession in the early 1990's (Nurminen *et al*. 2005) should be omitted from the prediction function. The variance of the model can be significantly greater than before, yet it will provide us with a less misleading measurement of uncertainty.

Heathcote and Higgins (2001) further point out that one feature of the regression models is that the boundaries of the fitted probability surface are a poorer fit to the observed data than the parts of the surface close to the mean of the predictor variates. Since it is reasonable to suppose that, for example, the most recent observed employment rates are the most accurate indicators of future employment, this warns us to be prudent in predicting by extrapolation from the fitted regression lines.

Van Hoorn and De Beer (2001) argue that for long-term forecasts, qualitative arguments about (working) life expectancy levels based on expert opinion or human judgment should carry more weight than historical extrapolations. This is despite the subjective element inherent in stochastic processes, with unknown covariates and a dynamic, non-stationary time series. Alternative means of incorporating expert opinion to base the regression model can be achieved by changing the parameters of the fitted model (Heathcote and Higgins 2001).

Forecasting beyond the observed data is risky because an improper forecasting method or wrong model may be chosen or the premise of the underlying regression model may change. This explains why the out-of-sample forecast errors are typically found to have much larger sampling errors than the residuals (model fitting error, *i.e.* the difference between the sample and the estimated value). Thus it is important to supplement point forecasts by computing prediction intervals (Chatfield 1993).

The small standard errors (and hence narrow confidence intervals) are fundamentally due to us modeling aggregate log odds of the state probabilities rather than directly modeling observations corresponding to the individuals in the Finnish working age population. There are several means of coping with this extra-binomial variation due to population heterogeneity (Williams 1982). In the present case, the problem was overcome by calculating standard errors pertaining to prediction intervals in lieu of standard confidence intervals. The prediction intervals for new observations are wider than the confidence intervals for the model fitted values. We computed pointwise intervals separately for each year; hence, these are narrower than simultaneous intervals that would adjust for all the estimated yearly values.

Even though the averages given by available working-life expectancy tables are appropriate, they may not describe the future for an individual because the attachment to the labor force appears either unusually high or unusually low. This situation can arise because there may be no sound statistical basis for an explicit assumption about his or her future employment. Forecasts often depend on contingencies to which one cannot assign probabilities, in which case a recourse is to substitute predictions with *scenarios*: optional coherent visions of future trends. Scenarios rely on assumptions about economic cycles, changes in mortality and other variates that demographers are unwilling or unable to project.

The use of working-life expectancy tables unavoidably imposes restrictions on the forecasts of future labor force participation of an individual to whom it is applied: a person's future is projected as an 'average' for the entire population. The working-life tables are calculated on the assumption that the number of lives who remain employed and those who enter and exit the labor force reflects the probabilities of making those transitions. The (implicit) Markov assumption for a working-life table means that the probability that a member of a population will be active next year depends only on whether he or she was active this year (Foster and Skoog 2004).

Ideally, more specific information would be needed in the form of individualized working-life expectancy calculations. In the preceding sections we showed that workers' degree of attachment to the labor force varies methodically with age, educational level, socioeconomic status, and gender. However, it also varies systematically with health, wealth, and a great number of other relevant determinants. The Finnish Centre for Pensions' current life expectancy tables do not explain dependence on those auxciliary variates because information about those variations is not registered or exploited. This heterogeneity will bias the resulting working-life projection if a person is not representative of the population used as the statistical base.

Table E.1

Predicted male future years of employment and their 90 percent intervals for ages x = 15–60 and years 2011–2015.

Age	Estimate	Predictions for men				
		2011	2012	2013	2014	2015
15	Mean	35.0	35.1	35.2	35.4	35.6
	Lower	34.3	34.4	34.5	34.7	34.8
	Upper	35.7	35.7	36.0	36.2	36.4
20	Mean	34.1	34.1	34.3	34.5	34.7
	Lower	33.4	33.5	33.6	33.8	33.9
	Upper	34.7	34.8	35.0	35.2	35.4
25	Mean	31.1	31.2	31.4	31.6	31.8
	Lower	30.6	30.7	30.8	31.0	31.2
	Upper	31.7	31.8	32.0	32.2	32.4
30	Mean	27.2	27.3	27.5	27.7	27.8
	Lower	26.7	26.8	27.0	27.2	27.3
	Upper	27.6	27.7	27.9	28.2	28.4
35	Mean	22.8	22.9	23.1	23.3	23.5
	Lower	22.4	22.6	22.7	22.9	23.0
	Upper	23.2	23.3	23.5	23.7	23.9
40	Mean	18.3	18.5	18.6	18.8	19.0
	Lower	18.0	18.1	18.3	18.4	18.6
	Upper	18.7	18.8	19.0	19.2	19.4
45	Mean	13.9	14.0	14.2	14.3	14.5
	Lower	13.6	13.7	13.9	14.0	14.2
	Upper	14.2	14.3	14.5	14.6	14.8
50	Mean	9.6	9.7	9.8	10.0	10.1
	Lower	9.3	9.5	9.6	9.7	9.9
	Upper	9.8	9.9	10.1	10.2	10.4
55	Mean	5.6	5.6	5.8	5.9	6.0
	Lower	5.4	5.5	5.6	5.7	5.8
	Upper	5.7	5.8	5.9	6.1	6.2
60	Mean	2.0	2.1	2.1	2.2	2.3
	Lower	1.9	2.0	2.1	2.1	2.2
	Upper	2.1	2.1	2.2	2.3	2.3

Table E.2

Predicted female future years of employment and their 90 percent intervals for ages x = 15–60 and years 2011–2015.

Age	Estimate	Predictions for women				
		2011	2012	2013	2014	2015
15	Mean	34.3	34.6	34.9	35.2	35.4
	Lower	34.2	34.5	34.8	35.1	35.3
	Upper	34.4	34.7	34.9	35.2	35.5
20	Mean	32.8	33.1	33.4	33.6	33.9
	Lower	32.8	33.0	33.3	33.6	33.8
	Upper	32.9	33.2	33.4	33.7	34.0
25	Mean	30.0	30.2	30.5	30.7	31.0
	Lower	29.9	30.1	30.4	30.6	30.9
	Upper	30.0	30.3	30.5	30.8	31.0
30	Mean	26.5	26.8	27.0	27.2	27.5
	Lower	26.5	26.7	27.0	27.2	27.4
	Upper	26.6	26.8	27.1	27.3	27.5
35	Mean	22.7	22.9	23.1	23.4	23.6
	Lower	22.6	22.8	23.1	23.3	23.5
	Upper	22.7	22.9	23.2	23.4	23.6
40	Mean	18.5	18.8	19.0	19.2	19.4
	Lower	18.5	18.7	18.9	19.1	19.4
	Upper	18.6	18.8	19.0	19.2	19.5
45	Mean	14.3	14.5	14.7	14.9	15.1
	Lower	14.2	14.4	14.6	14.8	15.0
	Upper	14.3	14.5	14.7	14.9	15.2
50	Mean	10.0	10.2	10.4	10.5	10.7
	Lower	9.9	10.1	10.3	10.5	10.7
	Upper	10.0	10.2	10.4	10.6	10.8
55	Mean	5.8	6.0	6.1	6.3	6.4
	Lower	5.8	5.9	6.1	6.2	6.4
	Upper	5.9	6.0	6.2	6.3	6.5
60	Mean	1.9	2.0	2.1	2.2	2.3
	Lower	1.9	2.0	2.1	2.1	2.2
	Upper	2.0	2.0	2.1	2.2	2.3

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The Finnish Centre for Pensions is a statutory co-operation body, expert and producer of joint services for the development and implementation of earnings-related pension provision. The aim of our research is to produce high-quality, widely applicable information for the evaluation and development of pension provision.

Eläketurvakeskus on työeläketurvan kehittämisen ja toimeenpanon lakisääteinen yhteistyöelin, asiantuntija ja yhteisten palveluiden tuottaja. Tutkimustoiminnan tavoitteena on tuottaa korkeatasoista ja laajasti hyödynnettävää tietoa eläketurvan arvioimiseen ja kehittämiseen.

Pensionsskyddscentralen är ett lagstadgat samorgan och sakkunnig inom verkställigheten och utvecklingen av arbetspensionsskyddet. Vi producerar gemensamma tjänster för arbetspensionssystemet. Vår forskning har som mål att ta fram högklassig information som nyttigörs på bred front vid bedömningen och utvecklingen av pensionsskyddet.