ELSI: The Finnish pension microsimulation model

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SUMMARY

In this report we overview the structure and functionalities of the pension microsimulation model ELSI. Developed and maintained by the Finnish Centre for Pensions, ELSI is used to forecast the long-term development of Finnish earnings-related pensions and national and guarantee pensions, which are paid by the Social Insurance Institution.

The main role of ELSI is to supplement the semi-aggregated long-term planning (LTP) model, which is also maintained by the Finnish Centre for Pensions. The LTP model groups people by sex, age and population state and simulates these groups' mean characteristics (such as wage earnings and earnings-related pensions). In contrast, ELSI employs individual-level microdata to simulate the life course of each individual separately.

The population modeled by ELSI comprises all adults who are covered by the Finnish social security system and those who have previously accrued earnings-related pension under the Finnish pension system. The input data used in the model is based on administrative registers and it covers the entire population of interest.

The ELSI model consists of modules that are run in succession. The population module simulates new people entering the population, deaths and transitions between population states. These include transitions to retirement and labor market dynamics. The earnings module simulates annual wages and pension-accruing social security benefits. Pension accrual and earnings-related pension amounts are calculated in the earnings-related pension module, whereas the national pension module simulates national and guarantee pensions. Income taxes and net earnings are handled in the income tax module.

The model produces an output dataset where each individual has a single row of simulated data for each simulated year. This dataset can then be analyzed either manually or by using ready-made functionalities in the ELSI results plotter. The individual-level output data produced by the model allows the user to study simulated pension distributions in detail and to analyze results in specific population subgroups. In addition to cross-sectional analysis, simulated life courses and earnings histories can be studied longitudinally.

Results calculated by the ELSI model are reported regularly as part of the Finnish Centre for Pensions' long-term projections. The model is also used to analyze the effects that various policy proposals would have on pension benefits. In the future the model will also be used to analyze the retirement incentives for those who have exceeded the earliest age of eligibility for old age pension.

TIIVISTELMÄ

Tässä raportissa kuvataan Eläketurvakeskuksen eläkkeitä mallintavan ELSI-mikrosimulointimallin rakenne ja toiminnallisuudet. Mallia käytetään Suomen työeläkejärjestelmän sekä Kelan maksamien kansan- ja takuueläkkeiden pitkän aikavälin kehityksen ennustamiseen.

ELSI-mallin pääasiallinen rooli on täydentää Eläketurvakeskuksen aggregaattitasolla toimivaa pitkän aikavälin suunnittelumallia (PTS-malli). PTS-mallissa ihmiset ryhmitellään sukupuolen, iän ja väestötilan mukaan ja mallinnetaan näiden ryhmien keskimääräisiä ominaisuuksia kuten palkkaa ja työeläkettä. Sen sijaan ELSI-mallissa käytetään henkilötasoista mikrodataa, jonka avulla jokaisen yksilön elinkaari simuloidaan erikseen.

ELSI-mallissa mallinnettava populaatio sisältää kaikki Suomen sosiaaliturvan piiriin kuuluvat aikuiset sekä sellaiset aikuiset, jotka ovat kartuttaneet eläkettä Suomen työeläkejärjestelmässä. Mallin lähtödata perustuu hallinnollisiin rekistereihin ja se kattaa kiinnostuksen kohteena olevan väestön kokonaisuudessaan.

ELSI-malli koostuu moduuleista, jotka ajetaan peräkkäin. Väestömoduulissa simuloidaan uusien henkilöiden saapuminen populaatioon, kuolemat sekä siirtymät väestötilojen välillä. Näihin siirtymiin kuuluvat muun muassa siirtymät eläkkeelle ja työmarkkinoiden dynamiikka. Ansiomoduulissa simuloidaan vuosipalkat sekä eläkettä kartuttavat sosiaaliturvajaksot. Työeläkekarttumat ja työeläkkeiden euromäärät lasketaan työeläkemoduulissa, kun taas kansan- ja takuueläkkeet simuloidaan kansaneläkemoduulissa. Verotusmoduulissa lasketaan tuloverot sekä nettoansiot.

Malli tuottaa tulosaineiston, jossa jokaisella henkilöllä on yksi rivi simuloituja tietoja jokaista simulointivuotta kohden. Käyttäjä voi analysoida aineistoa joko itse tai käyttää apuna mallin tulospoimurin sisältämiä valmiita työkaluja. Mallin tuottama henkilötason tulosaineisto mahdollistaa eläkejakaumien yksityiskohtaisen tarkastelun ja sen avulla voi analysoida tuloksia väestöryhmittäin. Poikkileikkaustietojen analysoinnin lisäksi aineistosta on mahdollista tarkastella ihmisten simuloituja elinkaaria ja ansaintahistorioita pitkittäisesti.

ELSI-mallilla laskettuja tuloksia raportoidaan säännöllisesti osana Eläketurvakeskuksen pitkän aikavälin ennustelaskelmia. Mallia käytetään myös arvioimaan sitä, kuinka ehdotetut politiikkamuutokset vaikuttaisivat eläke-etuuksiin. Tulevaisuudessa mallia tullaan myös käyttämään vanhuuseläkkeen lykkäyspäätösten laskennallisten kannusteiden arviointiin.

CONTENTS

Introduction

Earnings-related pensions are the lynchpin of the Finnish statutory pension system. They are defined benefits that accrue to wage and salary earners and to the self-employed from almost all work they do. Pension accrual is based linearly on annual wages, with no ceilings. Low earnings-related pensions are supplemented by national and guarantee pensions paid by the Social Insurance Institution.[1]

The Finnish Centre for Pensions is tasked with making projections and forecasts concerning the future of the statutory pension system. These are produced with the help of multiple in-house models. For long-term projections, the main tool used is the semi-aggregated long-term planning (LTP) model. The LTP model is useful for purposes of simulating earnings-related pensions on the aggregate level, but the structure of the model does not lend itself to situations where it is important to know incomes at the individual level, such as in the calculation of future pension distributions or in the detailed simulation of national and guarantee pensions. To better accommodate these needs, the Finnish Centre for Pensions developed the pension microsimulation model ELSI.

In this report we overview the structure and functionalities of the ELSI model. Earlier versions of the model are described in Tikanmäki et al. 2014b (in English) and in more detail in Tikanmäki et al. 2014a (in Finnish). Extensions of the model to cover national and guarantee pensions and income taxation are described in Sihvonen 2015 (in Finnish). A recent alternative model description can be found in Salonen 2020.

ELSI is a dynamic microsimulation model in the sense of time dynamics. It simulates the life course of each individual separately. Unlike many other models, ELSI does not use behavioral equations in determining model transitions. Instead, transitions between population states are based on Markovian type transition probabilities. The model has a cross-sectional aging process which builds a synthetic life history for each simulated individual. The model is implemented using Dyalog APL, although SAS is employed for some parts of starting data formation and for analysis of the results. The ELSI model is compared with other European pension microsimulation models in Dekkers & van den Bosch 2016.

The ELSI model has been used to evaluate the future development of benefits under the statutory pension system in Finland (Tikanmäki et al. 2017b and 2019). It has also been used to analyze proposed benefit changes in the pension system (Tikanmäki et al. 2015a and 2015b), the impacts on pension distributions from a hypothetical increase in income inequality due to changes in the nature of work and workplaces (Tikanmäki et al. 2017a) and to generate representative examples of working careers (Ritola 2019).

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1   See Tikanmäki et al. (2019) for an overview of the Finnish pension system and additional information on various pension benefits.

Simulated ELSI output data has been used in statistical analysis to illustrate employment and pension trajectories and educational transitions (Salonen et al. 2019). Trajectory analysis has also been used to validate simulated outcomes.

The model is updated on a regular basis. In connection with preparing its long-term projections, the Finnish Centre for Pensions compiles new starting data consisting of an updated model population every 2–3 years. Performed in parallel with updating the LTP model, these regular updates can include both parametric changes and small structural changes, such as adjusting pension ages or adding new pension benefits. In addition to regular updates, the model has also seen larger structural changes and new extensions. For example, the simulation of national pensions and income taxation were added to the model in 2015. In 2016, the results module was restructured and split into two parts, making the results plotter a separate tool. The earnings module was rebuilt in 2017.

Recently an extension was made to the model that calculates retirement incentives by computing the financial effects of postponing old-age retirement. However, these retirement incentives are not used in the actual simulation to help model the likelihood of transitioning to retirement.

In this document we describe the ELSI model as it exists at the beginning of 2020, when it is based on source data from 2008–2017 and the first simulated year is 2013. In the future, as new source data becomes available, the first simulation year can be gradually moved forward.

The role of the ELSI model is to supplement the semi-aggregated LTP model, which is based on roughly the same source data and which simulates similar population transitions as ELSI. In contrast to the individual-level simulation performed by ELSI, the LTP model groups people by sex, age and population state and simulates these groups' mean characteristics (such as wage earnings and earnings-related pensions). ELSI is aligned with the LTP model so that the key aggregate results are consistent.

A microsimulation model such as ELSI can produce additional information on pension benefits that cannot be obtained using semi-aggregated models. Even though pension accrual in the Finnish earnings-related pension system is linear and has no ceiling, some policy options are easier to analyze using microsimulation than semi-aggregated models. National and guarantee pensions are not linear, which makes microsimulation a natural approach for analyzing changes related to them. In fact, the LTP model's national pension module is aligned with the results of the ELSI model, so the two models complement each other.

There are also some static microsimulation models in Finland that cover national and guarantee pensions. The most notable of these is the SISU model maintained by Statistics Finland, which covers the personal taxation and social security systems in detail (see Statistics Finland 2019). However, simulation in the SISU model is based on a cross-sectional dataset from a single year, and it is mainly used to evaluate the immediate effects of policy reforms. The model includes static data ageing tools that can be used to age the SISU population a few years into the future before the microsimulation phase, but the simulation model itself does not have time dynamics.

Data

The target population of the ELSI model comprises all adults (18 years or older) who are in at least one of these two groups:

- Persons covered by the Finnish social security system
- Persons who have accrued earnings-related pension under the Finnish pension system.

As coverage under the Finnish social security system is based on permanent residence, the target population comprises the entire adult population of Finland and those adults living abroad who have previously accrued earnings-related pension under the Finnish pension system.

The individual-level data used in the ELSI model is primarily based on the following sources:

- The Finnish Centre for Pensions register of earnings-related pension contingencies and earnings-related pensions in payment
- A register of statutory pensions and country of residence maintained by the Finnish Centre for Pensions and the Social Insurance Institution
- An earnings register maintained by the parties to the earnings-related pension scheme that covers pension-accruing periods of work and pension-accruing periods of receiving social security benefits
- Statistics Finland data on highest education level
- Data on marital status and primary residence from the Digital and Population Data Services Agency.

These sources are used to create a primary source dataset that contains individual-level information on the target population for each of the years 2008–2012. The yearly source data is of the same form as the output data generated by the model for the simulated future years (see Table 1).

Source data is also created for 2013–2017. This data is used to calibrate the simulation and for in-sample testing to validate parts of the model by comparing the simulated results for these years with the actual data.

The ELSI model can be run either with a full dataset that includes all people in the target population or with a smaller sample.

Data structure

The micro-level source data and the output datasets of ELSI modules are Dyalog APL component files, with the data for each year in a separate component. The first three components of an ELSI output data file contain additional information about the data.

The first component provides general information such as what years are included in the data, what was the first simulation year and the sample size, what versions of the simulation modules were used to produce the file and when the modules were run. It also lists the path to the ELSI source data used and the path to other external datasets that were used in the simulation, such as results from the LTP model.

The second component includes a description of the variables in the data, in the same way as Table 1. The third component consists of standardized results, most of which are calculated in the results module. From the fourth component onwards, each component consists of the entire actual or simulated microdata for a given year, starting with the first source data year (2008).

Table 1 shows a list of the variables that each individual in the data has for each year. The third column tells which module of the model produces the variable in question for simulated years.

Table 1.
Variables in the ELSI model

Technical name	Description	ELSI module
EID	Anonymous personal identifier	Population
SP	Sex	Population
TILA	Population state	Population
SA	Year of birth	Population
KA	Year of death	Population
TKA	Starting date of current earnings-related pension	Population
TURA	Duration of working life since age 18 (years)	Population / Earnings
KE	Accrued earnings-related pension (€/month)	Earnings-related pension
ME	Earnings-related pension in payment (€/month)	Earnings-related pension
PA	Salary earnings (€/year)	Earnings
YA	Earnings from self-employment (YEL, MYEL) (€/year)	Earnings
VPR	Share of earnings-related parental benefits for which pension accrues (€/year)	Earnings
TPR	Share of earnings-related unemployment allowance for which pension accrues (€/year)	Earnings
APT	Share of earnings for other unsalaried periods (€/year)	Earnings

Technical name	Description	ELSI module
TPT	Share calculated for the projected pension component of earnings for unsalaried periods (€/year)	Earnings
VEKL	VEKL (Pension benefit accrued from the care of own children under age 3 and from studies leading to a degree, €/year)	Earnings
KOUL	Level of highest education (5 levels)	Population
MAA	Country of residence (3 categories)	Population
TEM	Earnings-related pension paid over one year, i.e. pension expenditure (€/year)	Earnings-related pension
ELAK	Pension accrued in retirement, excluding accrual for period of partial old-age pension (€/month)	Earnings-related pension
MTM	Paid earnings-related pension contributions (€/year)	Earnings-related pension
TAEL	Projected pension component (€/year)	Earnings-related pension
TANS	Earnings on which projected pension component is based (€/year)	Earnings-related pension
TEVV	Deduction for early retirement on an earnings-related pension (€/year)	National pension
TELK	Increment for late retirement on an earnings-related pension (€/year)	National pension
J63K	Earnings-related pension that has accrued after age 63 (€/year)	National pension
VEKLK	Pension accrual under VEKL (€/year)	National pension
LE	Earnings-related surviving spouse's pension + pensions from abroad (€/month)	National pension
AM	Type of family or type of housing (1=marriage, 2=cohabiting, 3=single)	National pension
KEL	National pension (€/month)	National pension
AAS	Time of residence in Finland as of age 16 (years)	National pension
TE	Guarantee pension (€/month)	National pension
KELME	National pension expenditure (€/year)	National pension
TEME	Guarantee pension expenditure (€/year)	National pension
NTULO	Net income (Salary earnings + Earnings from self-employment + Earnings-related pensions + Kela pensions – Taxes, €/year)	Income taxation
NELAKE	Net total pension (Share of gross total pension defined by the ratio of net income to gross income, €/year)	Income taxation

A person's level of education is the highest level of educational attainment so far. The model uses a five-tier classification:

1. Primary education at most

2. High school

3. Vocational school

4. Lower tertiary education

5. Higher tertiary education.

Lower tertiary education refers to degrees that take 2–4 years to complete after upper secondary education. These include bachelor's degrees and polytechnic degrees. Higher tertiary education includes master's degrees and doctorate degrees. In some parts of the model educational levels 2 and 3 are grouped together, giving a simpler, four-tier classification.

Country of residence can have one of three values:

1. Finland

0. Country with which Finland has a social security agreement

-1. Other country

This division is necessary since a person's eligibility to receive certain pension benefits is dependent on whether or not their country of residence has a social security agreement with Finland.

Source data quality and imputations

The data used in creating the source datasets is generally of high quality and comprises all people covered by the Finnish earnings-related pension system. Data on pensions in payment is drawn from the same source that the Finnish Centre for Pensions uses to create the corresponding official statistics. The earnings register that is used to calculate yearly accrued earnings-related pension rights into the source data is the same register that is used by pension providers to calculate the amounts of starting pensions.

However, not all source data can be picked straight from the registers. For self-employed people, pension accrual is based on so-called confirmed income, which is meant to reflect the value of the individual's work. The Finnish Centre for Pensions does not have access to comprehensive individual-level data on confirmed incomes, so missing data needs to be imputed. This imputation is based on the confirmed incomes of people when they first started in self-employment. These are imputed for future years and scaled so that on the aggregate level, they match the confirmed income of all self-employed people by sex and age.

Some information relevant to the calculation of national pension must also be imputed into the source data. This includes information about a person's family structure and time lived in Finland as of age 16. Data on marital status and primary residence is used to identify couples.

Population states

Population modeling in ELSI is based on 21 population states. The population state of an individual depicts their main type of activity during a given year. A person is in a single population state for one year at a time.

Within the model, population states are referred to with two-letter codes, as shown in Table 2. These codes are based on the names of the population states in Finnish.

There are 11 population states for retired people, mostly corresponding to the various types of pensions that a person can receive. In the case of partial old-age pension (states OV and Ov) and partial disability pension (states OT and Ot), there are two population states for both, corresponding to whether or not the person is working while drawing a pension. This makes it easier to simulate earnings for these people. Those receiving a full disability pension for the first consecutive year also get their own population state T1, as these people are more likely to transition out of full disability pension than those who have been receiving it for longer.

Those who are not retired and who are employed are divided into three population states based on length of consecutive employment. People who are employed for the first or second consecutive year are placed in states A1 and A2, respectively. Those who have been consecutively employed for longer are placed in state AK. This division makes the modeling more realistic, since it is more likely for a person to transition out of employment in the first years of being employed. States A1, A2 and AK are also called active states.

People receiving unemployment benefits are also divided into two states based on whether they are on the unemployment pathway to retirement. This is because persons on this pathway (in state AL) are less likely to return to employment. The general unemployed state AT includes both those receiving an earnings-related unemployment allowance and those receiving a basic unemployment allowance from the Social Insurance Institution.

Before a person can retire on a full disability pension, they have had to receive sickness allowance for the maximum period of about one year. For this reason, we have included a separate state AS for these allowance recipients. It is important to note that people who receive a sickness allowance that does not lead to full disability pension are not included in this state. Instead, people in other population states have spells of receiving the allowance that are simulated in the ELSI earnings module.

People who are outside the labor force for other reasons are in one of three states. State Mu is for those people who have accrued no earnings-related pension; these are mostly young people and recent immigrants. Those who have previously accrued earnings-

related pension are either in state Ak or SY. The regular inactive state Ak is meant to be relatively temporary. In contrast, people in state SY are much less likely to transition to other population states.

The reason for having three states for people outside the labor force is to make the modeling more realistic: there are many different reasons for being outside the labor force. Some of them tend to last only a brief period, while others are more permanent. The three states include, for example, non-employed students, those doing mandatory military service, those on child home care allowance or on a longer sickness allowance (that does not directly lead to full disability pension) and socially excluded people.

The population state of people in the source data is based on their status at the end of the year in question. The order in which different population states are generally prioritized is shown in Table 2, with states with higher priority higher up the list. The following paragraphs describe how the different population states are generated into the source data.

Starting from the top, people who are deceased are placed in state KU. However, people who have died in December of the year in question and who have received a pension in December are placed in their retirement state instead, only moving to state KU the next year. This is done so that the number of pensioners at year-end matches up with Finnish Centre for Pensions statistics.

Next, retired people are placed into their highest priority retired state, with old-age pension being the highest prioritized. People who are not retired and who are employed at the end of the year are placed into one of the primarily employed states A1, A2 or AK according to how many consecutive years they have been primarily employed at the end of the year.

People who are unemployed at the end of the year are placed into states AL and AT according to whether they are on the unemployment pathway to retirement. Those who do not have a state at this point go into either state Ak or Mu depending on whether or not they have accrued earnings-related pension. People who are in state Ak for at least the fifth consecutive year are put into state SY.

Finally, people who are in state A1, A2, AK, AT, AL or OE are moved to state AS if they begin to receive a full disability pension the following year. This means that state AS can only be deduced into the source data when data are available on full disability pensions for the year following the year of interest.

Table 2.
Population states in the ELSI model

State	Description
	Deceased
KU	Deceased
	Retired
VE	Old-age pension
OV	Partial old-age pension and employed
Ov	Partial old-age pension and not employed
T1	Full disability pension for the first consecutive year
TK	Full disability pension for at least the second consecutive year
OT	Partial disability pension and employed
Ot	Partial disability pension and not employed
OE	Part-time pension
TU	Years-of-service pension
KV	National old-age pension only
KT	National disability pension only
	Sickness allowance preceding full disability pension
AS	Sickness allowance preceding full disability pension
	Primarily employed ("active")
A1	Primarily employed for the first consecutive year
A2	Primarily employed for the second consecutive year
AK	Primarily employed for at least the third consecutive year
	Unemployed
AL	On the unemployment pathway to retirement
AT	Unemployed (excluding those on the unemployment pathway to retirement)
	Outside the labor force for other reasons
SY	Permanently outside the labor force but has accrued earnings-related pension
Ak	Outside the labor force but has accrued earnings-related pension
Mu	Outside the labor force and has not accrued earnings-related pension

Estimating starting parameters and distributions

The micro-level source data is used to estimate starting parameters and distributions that are used in the actual simulation model. In most cases these parameters and distributions are calculated straight from the empirical data and used as-is. However, ad hoc adjustments are sometimes made if there is not enough empirical data or if a shock (such as a change in the pension system or a disruption in the economy) is deemed to have made some part of the source data unrepresentative of a longer-term stable situation.

The most important estimated parameters are transition probability matrices that give the probabilities of transitioning from one population state to another during a given year from 2011 to 2017 for those people whose country of residence does not change during the year. Transition probabilities are calculated by country of residence (3 categories), sex, age (18–110), highest education (4 levels, used only for people residing in Finland), starting state and end state. This yields three matrices of transition probabilities for each year. The matrix for residents of Finland thus has the dimensions 2×93×4×21×21, and the two matrices for people living outside Finland have the dimensions 2×93×21×21. These are used as a basis for simulating state transitions in the population module.

Other distributions estimated from the source data are not calculated for each individual year, but rather as an average from the last three years for which data is available, so generally 2015-2017. These include probabilities for emigrating from and immigrating back to Finland by age and sex, and probabilities of population state transitions for emigrating and immigrating individuals. Also, distributions of educational levels and population states are calculated for people entering the target population. This is done separately for 18-year-olds and new immigrants. Finally, the probability that a person's highest education (5 levels) rises is calculated by starting educational level, new educational level, age and sex, giving a 5×5×93×2 matrix.

Model structure

Like most extensive microsimulation models, ELSI has a modular structure. Each module is implemented as a separate APL workspace. Each module goes through the entire simulation data year-by-year for all simulation years. Only then can the resulting data be fed into the next module. This structure means that there can be no feedback from a module to any previous module in the chain.

Figure 1.
Modular structure of the ELSI model.
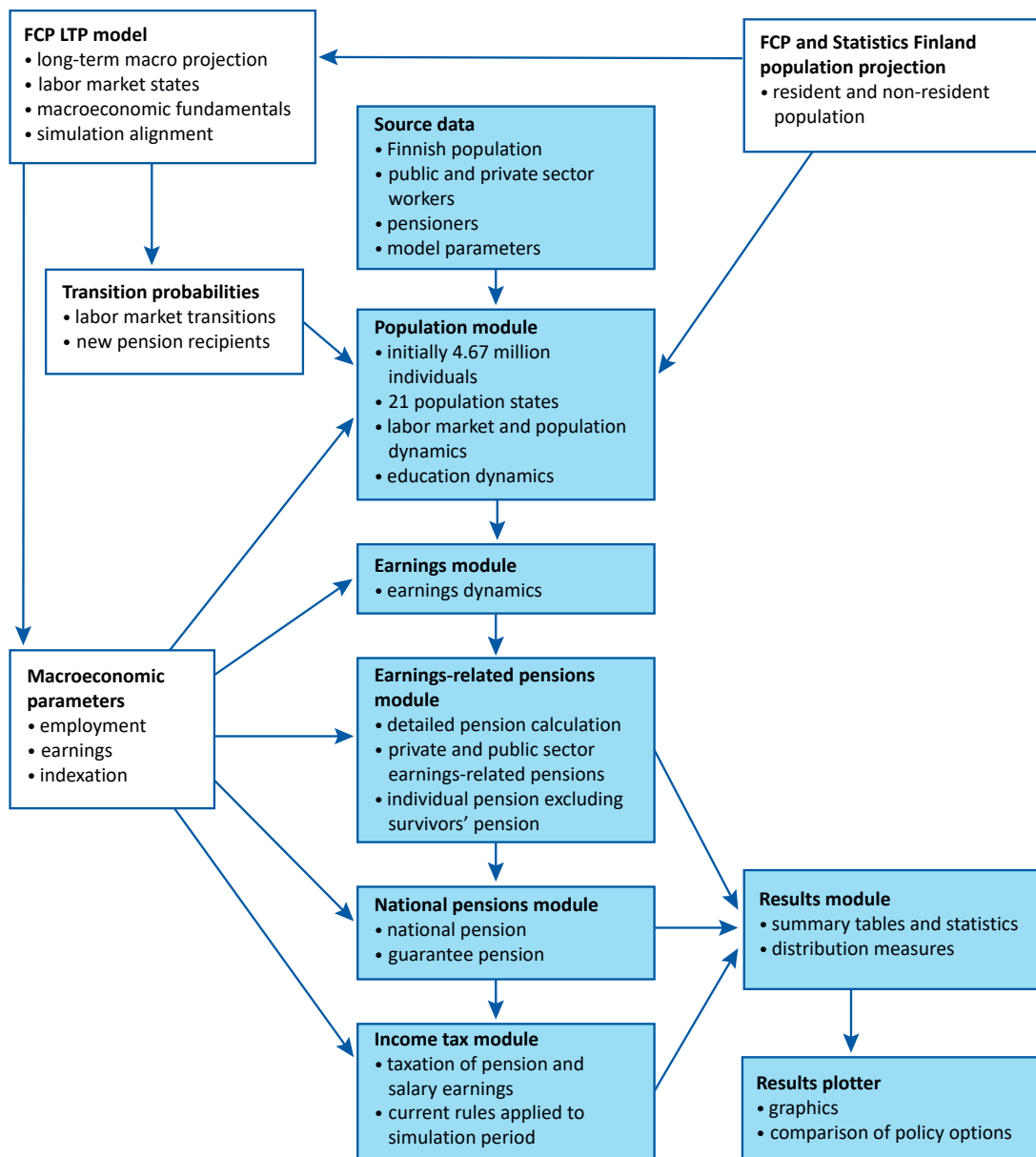
Most transitions in the model occur in the middle of the year, more precisely, at the beginning of July. These include population state, educational level and residence status transitions. Earnings and pensions in payment are calculated separately for the first half of the year and for the second half of the year. Simulation of the first half is based on the population state, education level and residence status for the former year. The earnings and pensions of the second half of the year are based on the characteristics for the year in question. However, only annual information on earnings and pensions is stored to the microdata.

Population module

The population module is the first simulation module in the ELSI model. It simulates the development of the target population by generating new cohorts that enter the population and by modeling immigration, emigration, educational dynamics and transitions between population states. State transitions include, for example, labor market dynamics, transitions into retirement and deaths. The first simulated year is 2013, and simulation is generally done until 2085.

Population state transitions are modeled with the help of the 21 population states described earlier. With some exceptions, population state modeling has a simple Markovian structure, where the only factors affecting the probabilities of transitioning into other states are country of residence, sex, age, education level (for residents of Finland) and current population state. In practice, this means that for each of the three values for country of residence, we have a transition probability matrix like the ones estimated from the source data.

There are two transitions that are modeled with longer transition paths within the Markovian framework. The population state of fully employed people has been divided into three states to better model the higher unemployment risk of newly employed people; the only way to get to population state AK is to move from A1 to A2 to AK. A similar arrangement exists with full disability pension. The only way to transition to population state TK is to go through state T1. This makes the modeling more realistic as the first year on disability pension holds a significantly higher probability of both rehabilitation and death. In most cases, people must also go through state AS to get to T1. This helps to model the fact that it is usually necessary to receive sickness allowance for about one year before gaining eligibility to a full disability pension.

One notable exception to the Markovian structure of population state transitions is that for people in state AK, the length of working life influences the probability of their remaining employed. For those whose working life covers at least 75% of their adult life, the probability of remaining in state AK is increased, while the probability of transitioning to inactive state Ak is decreased. The opposite is done for people who do not meet this condition in order to keep the aggregate transition probabilities equal to those given by the corresponding transition probability matrix. Another exception is that only those people who meet the length of working life requirement (38 years) for a years-of-service pension are given the chance of transitioning to the years-of-service pension state TU.

The following paragraphs detail the steps that take place as the population module simulates a single year.

The basis for the yearly simulation is, naturally, last year's simulated data (or actual data in the case of the first simulation year). Population state transitions and immigration and emigration are modeled to occur in the middle of the year, so at the beginning we are operating with last year's population in last year's population states. For people in population states where everyone is employed (states A1, A2, AK, OT, OE and OV), the length of working life is advanced by 0.5 years to account for the first 6 months of the year. People in other than these states can also have employment spells, but they are modeled later in the earnings module. Also, people in employed states can have short periods of unemployment or other inactivity that are similarly modeled later in the earnings module.

For people who are already in the model population, emigration and immigration are modeled with probabilities calculated from the source data. The only factors affecting the probability of emigration from or immigration back to Finland are the person's age and sex. These probabilities are unchanged throughout the simulation period.

Next, new people are added into the model population. 18-year-old men and women are generated to match the numbers of the population projection. Each of them is randomly given a starting education level based on an education distribution calculated from the source data and a starting population state based both on a state distribution calculated from the source data and the state distribution for 18-year-olds in the LTP model for the simulation year in question. New immigrants are generated into the model population in such numbers that yearly net migration (new yearly immigrants + yearly immigrants already in the model population – yearly emigrants) is at the level given by the population projection. New immigrants are also given starting education levels and population states based on distributions calculated from the source data.

Educational levels are adjusted based on probabilities calculated from the source data. The factors that define the probabilities for a rise in education level are current education level, age and sex. The level can rise multiple steps at a time but can never go down.

If the simulation year is one of the first few years (a year for which source data exists), the actual transition probability matrix estimated from the source data for that year is used to model transitions between population states. Otherwise a transition probability matrix needs to be created.

The transition probabilities used for the first simulation year without source data (2018) are based on the average transition probabilities for 2014–2017, which are updated as described below. For subsequent years, the transition probability matrix for a given simulation year is created by updating the matrix used for the previous year.

Mortality rates (transitions into state KU) are updated by adjusting the previous year's mortality rates by the change in the sex and age specific mortality rates found in the population projection. The way in which mortality is distributed within these groups is therefore based on mortality rates calculated from the source data. To illustrate this

point, let us assume that an examination of the source data shows that for 60-year-old men, those who are in state TK and have upper tertiary education are 4 times as likely to die during a given year as those who are in state AK and who have no more than primary education. This 4:1 ratio will then hold for the entire simulation period, even as the mortality rates for 60-year-old men are adjusted down according to the population projection.

Other transition probabilities between population states are updated with the help of probabilities and state distributions from the LTP model. However, since the LTP model has fewer population states than ELSI and does not differentiate between different educational levels, LTP transition probabilities cannot be used as such in ELSI.

In general, the ELSI transition probability matrix is updated by multiplying the previous year's probabilities in such a way that they would match the corresponding LTP probabilities if ELSI population states were aggregated to match LTP population states. In situations where a single LTP population state covers multiple ELSI states, a common multiplier is used for all states. For example, the LTP model only has a single state for primarily employed people. If in ELSI we needed for some age and sex group to decrease the probability of transitioning from primary employment to old-age pension by 10% (to match the LTP model), we would multiply transition probabilities from each of the states A1, A2 and AK to VE by 0.9.

Different transition probabilities for different educational levels are created in such a way that on the aggregate level, weighted by the number of people at different educational levels, they equal the corresponding LTP probability. The ratios between transition probabilities for different educational levels are generally based on the transition probability matrix estimated from the source data. To give an example, say that in the source data 35-year-old women in state AK with lower tertiary education have a 40% higher probability of transitioning into state AS than those with upper tertiary education. This ratio will be fixed during the entire simulation period, as the aggregate probability of transitioning from state AK to state AS for 35-year-old women is adjusted to match that of the LTP model.

There is a special update procedure for the main labor market dynamics, i.e. transitions between primarily employed states A1, A2 and AK, the inactive state Ak, the unemployment state AT and the residual state Mu. These are updated in such a way that the ratios of primarily employed and unemployed people to the population roughly match the numbers in the LTP model.

As retirement ages rise, it is necessary to simulate some transitions at ages where they have not previously been possible. When updating transition probabilities in these cases, the way in which educational level affects the probability of transition is taken from the age (or a range of ages) where the corresponding transition was last possible in the source data. For example, as the retirement age rises, it is possible to become unemployed (transition into state AT) at older ages. The way in which educational level affects the probability of becoming unemployed at these ages is taken from the probabilities of transitioning into unemployment at age 62, as calculated from the source data.

After the transition probability matrices have been updated for the current simulation year, they are used to randomly draw for each individual a new population state that they will have for the final 6 months of the current simulation year and for the first 6 months of the next simulation year. For people whose new population state is one where everyone is employed, length of working life is again advanced by 0.5 years.

Earnings module

The main role of the earnings module is to simulate annual wages for individuals who are in active states (A1, A2 and AK). To be more precise, the module simulates the sum of salary earnings and the insured (confirmed) income of the self-employed. Technically these two sources of income are separated in the model only for the early simulation years. No new self-employed people are created in the simulation model, so when the old self-employed people retire or become unemployed or inactive, they are replaced by wage earners. The lower earnings level of the self-employed is taken into account in the simulated earnings distribution.

The earnings module also simulates those social security benefits that accrue earnings-related pension rights. The length of working life is recalculated since in this module, we have additional information on short career breaks corresponding to periods of receiving social security benefits. Pension accrued from studies leading to degrees is also calculated in this module.

The wage simulation of the earnings module has been updated in 2017 by fitting a time series model to Finnish earnings data from 2005-2015. The details of the model's selection and estimation processes are presented in Tarvainen 2017. Some parameters used in the ELSI model differ slightly from those estimated by Tarvainen because the wage process has been recalibrated.

There are in fact two separate wage models in the wage module. For new entrants into the model population, initial wage is simulated using a static model. The wages for people already in the model population are simulated using a dynamic model. Technically, preliminary wages are simulated in the background for all working-aged individuals regardless of their state. These wages are written to the simulation data only if the individual is in one of the active states or partial pension states. In the case of partial pension states, the wage given by the wage process is halved.

The dynamic model for wages is of the following form:

$$z_{i,t} = k_1 z_{i,t-1} + k_2 z_{i,t-2} + P(sex, age, education) + T(state) + K_1 u_i + K_2 \epsilon_{i,t},$$

where $z_{i,t}$ is the logarithm of the wage of individual i at year t and u_i is a permanent random factor for each individual. This term represents differences in occupations and other permanent variation among individuals, whereas the random factor $\epsilon_{i,t}$ represents the annual variation of the individual's wage. The random variables u_i follow an asymmetric Laplace distribution and the stochastic processes ϵ_i are i.i.d.

sequences of normally distributed centered random variables with variance σ^2 that is determined by the person's sex. The wage processes of different individuals are independent. The parameters of the dynamic wage process are described in appendix 1.

The static model for wages of new individuals resembles the dynamic wage model, with a couple of exceptions. Obviously, there are no time dynamics. Also, the state-dependent term T is missing. The parameters of the static model differ from those of the dynamic model. The static model for wages is of the form:

$$z_i = \tilde{P}(sex, age, education) + \tilde{K}_1 \tilde{u}_i + \tilde{K}_2 \tilde{\epsilon}_i$$

Again, $\tilde{u}_i$ follow an asymmetric Laplace distribution and $\tilde{\epsilon}_i$ a centered normal distribution. However, the interpretation is different than in the dynamic model because no time dynamics are involved. In the static model the random variables $\tilde{u}_i$ and $\tilde{\epsilon}_i$ together represent the variation among individuals. The parameters of the static wage model are represented in appendix 2.

Simulation of the wages for partially retired people follows the general procedure. Some fully retired people in states VE and TK may also have wage earnings. These incomes are modelled rather coarsely by randomly assigning smallish earnings to new retirees and to part of those old retirees who have worked the preceding year. The amounts roughly match the official statistics.

Simulation of social security spells is different for different social security benefits. Unemployment spells are mainly based on states AT and AL, with a couple of exceptions. There is the state AS for sickness benefits preceding disability pension, but these periods do not accrue pension[2]. Shorter sickness benefits, parental benefits and job alternation leaves are simulated in parallel to the state dynamics. The pension that accrues from studies leading to a degree is based on the simulated changes in educational levels.

As said earlier, pension accrual based on earnings-related unemployment spells is based on the person's population state. However, some unemployment spells are not earnings-related and hence do not accrue pension. In the model, 10% of new entrants to state AT do not accrue any pension[3]. Pension no longer accrues from the third consecutive year in state AT[4].

Parental leaves are based on simulated births, which in turn are based on age and sex specific fertility rates. These rates are applied independently of the population state. For women, age specific fertility rates come from Statistics Finland's official population projection. For men, we have used women's fertility rates with a two-year shift toward

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2   These periods are taken into account as part of the projected pension component.
3   About 90% of wage and salary earners are members of an unemployment fund (Findikaattori 2020). Only fund members are eligible to receive earnings-related unemployment benefits.
4   The maximum length of an earnings-related unemployment spell is generally 400 working days. The most notable exception is the unemployment pathway to retirement.

older ages and a 2% reduction. This assumption is based roughly on observed history, see e.g. Nisén et al. 2014.

In the model we have assumed that women use all the earnings-related maternal and parental leaves (10 months) to which the family is entitled. Men use the share dedicated to fathers (9 weeks). We have assumed that all women who are not in active states and who are entitled to home care allowance, will use the benefit. For women in active states, 40% will use the home care allowance, while 0% of men in active states and 50% of other men entitled to the benefit will draw the home care allowance. These parameters are chosen in such a way that the simulation results fit the observed history on the aggregate level.

For sickness allowance and job alternation leave rates we have simple separate age and sex specific profiles. These benefits are possible for people in the three active states. In the model, pension-accruing periods of sickness allowance last for 2 months and job alternation leaves last for 6 months.

Earnings-related pensions module

The earnings-related pensions module is purely deterministic. The size of each pensioner's pension is calculated based on the career and earnings simulated in the preceding modules.

The calculation of earnings-related pension is rather straightforward once career and pension transitions have been simulated. Pension benefit rules are applied at a very detailed level. Benefit rules have varied historically, along with changes made to pension legislation. Some of the transitions from old rules to new are still ongoing. Given these differences in benefit rules, all pensions are calculated based on private sector employees (TyEL) rules. The benefit rules are described in a nutshell in Tikanmäki et al. 2019.

Accrued pension is calculated based on earnings simulated in the earnings module. The accrual rates are age specific until 2025. Accruals from social security benefits and studies leading to a degree are added to the accrued pension.

A pension is calculated for the first time after a transition to a pension state. The pension is recalculated if the pension state changes to another pension state. A pension ends when the pensioner dies. A disability pension can also end with a transition to another population state. All pensions in payment are indexed annually using the earnings-related pension index. It is possible to accrue additional pension while receiving a pension. These new pension accruals are added to pensions in payment when a disability pension is converted into an old age pension and at the age at which the insurance obligation ends[5].

Pension increases for late retirement and reductions for early retirement are calculated based on cohort specific age limits. Starting pensions are adjusted with a cohort

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5   68–70 years depending on the birth cohort.

specific life expectancy coefficient. The most recent confirmed coefficient is used for people whose cohort specific coefficient is not yet confirmed in the simulation.

The earnings-related pension module produces both monthly pension (variable ME) and individual level pension expenditure (TEM) that takes into account the amount of time of receiving a pension during the given year. For summing aggregates, the latter gives more precise results. Since all transitions in ELSI occur at the beginning of July, possible options for the amount of time spent receiving a pension during a given year are 12 months, first 6 months or last 6 months.

The module also simulates some other results, including the sum of pension contributions paid by the employee and the employer. The earnings base for the projected pension component of disability pension provides a rather robust denominator for computing replacement rates.

National pensions module

The amounts of national pension and guarantee pension are calculated in the national pensions module.

National pension supplements the income of pensioners who receive a small earnings-related pension or no earnings-related pension at all. The full monthly amount of national pension depends on whether the person is living alone (662.86 € in 2020) or cohabiting (591.79 € in 2020). These full amounts are paid only to people whose monthly earnings-related pension is under a given limit (56.04 € in 2020). Above this limit, each additional euro of earnings-related pension reduces the amount of national pension by 50 cents.

The purpose of the guarantee pension is to ensure a minimum pension for pensioners living in Finland (834.52 € per month in 2020). If a person's pension would otherwise be less than this, the difference is paid in the form of a guarantee pension. National or guarantee pension eligibility requires that the individual has lived for at least three years in Finland or in certain countries with which Finland has a social security agreement.

In the model, people receive national pension in old-age pension states (VE, OV, Ov, KV) and in disability pension states (T1, TK, KT) if they otherwise fulfill the necessary requirements. Guarantee pension can be paid to people in states VE, KV, T1, TK and KT.

Length of time lived in Finland and in certain countries with which Finland has a social security agreement may affect the level of national pension. If the person has spent less than 80% of their time between age 16 and the start of the pension in these countries, the amount of national pension will be reduced. This is why it is necessary in the population module to separately model residence in social security agreement countries and other foreign countries.

Because the amount of national pension payable depends on the person's cohabiting status, this status is also simulated in the national pensions module. The probabilities

of changes in cohabiting status are estimated from actual data and are dependent on age, sex and previous cohabiting status. These same factors are also used to randomly draw a cohabiting status for new recipients of national pension.

Survivors' pensions and pension income from abroad reduce the amount of national pension and guarantee pension payable. These pensions are not simulated in detail in ELSI. However, a rough estimate is made in the national pensions module, and they are taken into account when calculating national and guarantee pensions.

To maintain the purchasing power of national and guarantee pensions, their full amounts are tied in current legislation to the national pension index, which is in turn tied to inflation. In addition, these benefits have seen many discretionary increases to stop them from falling too far behind the development of earnings-related pensions and to alleviate poverty among pensioners. To reflect this reality, the base assumption in the model is that in the long run, the full amounts of national and guarantee pensions develop in sync with an index where the weight of inflation is 50% and that of wage growth 50%. This roughly mirrors the rate at which these benefits have increased in recent decades.

Like the earnings-related pensions module, the national pension module also produces two kinds of variables for national and guarantee pensions. The variables KEL and TE give the monthly amount of a person's national and guarantee pensions. The yearly expenditure variables KELME and TEME take into account the time spent receiving the respective pensions during the given year.

Income taxation module

ELSI's final simulation module concerns income taxation. The goal is to calculate net wage and pension income. The results can be used, for example, to calculate net replacement rates, to assess the distributional effects of income taxation or to analyze incentives to retire or continue working.

The module simulates state and municipal taxation and mandatory tax-like social insurance contributions, such as earnings-related pension, health insurance and unemployment insurance contributions. Church tax can also be simulated.

Up to the current year, the module uses actual taxation parameters (such as tax rates and tax bracket thresholds) for the simulation year in question. For future simulation years, the parameters are based on the latest actual parameters. The future development of monetary parameters is by default indexed to the growth of wages. Alternatively, there is an option to index them to inflation. Tax and contribution rates are held at the level specified in current legislation, apart from the earnings-related pension contribution rate, the future values for which are taken from the LTP model.

Municipal taxes are calculated based on the average municipal tax rate. If church taxes are included in the simulation, they are also calculated based on the average church tax rate.

The module produces one variable for net income (NTULO) and one for net pension (NELAKE). Net pension is calculated by multiplying gross pensions with the ratio of total net income to total gross income.

For a detailed examination of the taxation of wages and pensions in Finland, see the total pension report published yearly by the Finnish Centre for Pensions (Ritola and Knuuti, 2020).

Results module

After the actual simulation phase, ELSI output data can be fed into the results module. This module takes the individual level data and calculates aggregate level results for each simulation year. Result variables include pension expenditures, replacement rates and numbers of starting pensions by pension type, and key statistics on wage and pension distributions by sex.

It is not necessary to run all the simulation modules described above before calculating the results. The results module checks which simulation modules have been run and only tries to calculate the results that can be obtained from the given data. The earliest point at which results can be created is directly after running the earnings-related pensions module.

The results module's output data file includes both complete simulated microdata for each year and aggregate level results calculated by the module.

Results plotter

The results plotter can be used to easily plot and compare results produced by the results module. It is separate from the actual calculation of results, which makes it easier to compare results between multiple simulation runs. For example, to assess the effects of a change to pension legislation, we would first run the ELSI model with current legislation, then run it again with the revised legislation and compare key results with the results plotter. The plotter can also read information from LTP model output datasets, which allows the user to compare some of the results from the ELSI model with the corresponding LTP results.

The plotter features predefined sets of key results that can be plotted together with a single command and an option to automatically adjust monetary values for inflation. It uses Dyalog APL's RainPro graphics engine.

Examples of figures drawn using the results plotter are provided below under the heading Long-term projections.

Alignment with the LTP model

The role of the ELSI model is to supplement the semi-aggregated LTP model. The LTP model is described in Tikanmäki et al. 2019.

In both models the main input data is based on the same individual-level data on incomes, accrued pension rights and pensions in payment, given separately for different pension schemes. For use in the LTP model, this data is aggregated over population state, sex, age and pension scheme. The ELSI model does not need information on how these variables are distributed between pension schemes, so the data is aggregated over persons, giving a dataset where each person has a single row of data for a given year.

The base population and the population states are also almost the same for the two models. There are, however, some differences in the dimensions covered by the models. Educational level is one of the key dimensions in the ELSI model, but it is not taken into account in the LTP model. On the other hand, the LTP model runs scheme-wise, whereas the ELSI model operates as if the earnings-related pension system were just one single scheme.

The practical application of state transition probabilities differs slightly in the LTP and ELSI models. In the LTP model, the share of people transitioning from one state to another is always exactly the share indicated by the corresponding transition probability. In ELSI, on the other hand, transitions are modeled probabilistically on the individual level, so there is some Monte Carlo variation in the share of people who transition from one state to another.

These differences in the modeling techniques underscore the importance of having adequate alignment methods to guarantee that the models tell the same story.

To run the ELSI model it is necessary to have certain output data from a corresponding simulation run of the LTP model. This data includes yearly information about LTP transition matrices between model states, state distributions, wage sums by sex and age, pension contribution rates and GDP. The data is automatically read into the ELSI model, and it is used to automatically align the model in a way that ensures that key variables match those of the LTP model.

Transition matrices in ELSI are updated every simulation year in such a way that the most important aggregates for each age and sex group, such as mortality, number of employed people and number of retiring people, match with the LTP model. As a byproduct, this yearly balancing reduces Monte Carlo error in the ELSI model.

Yearly information on inflation, wage growth and various pension indices is read from a parameter table that is common to both the LTP and ELSI models.

In the automatic alignment process, the data only flows from LTP to ELSI. In addition to this automatic alignment process, parts of the models are sometimes calibrated

manually. In this case it is also possible to make changes to the LTP model based on ELSI results. For example, the national pension calculation in the LTP model is aligned with ELSI results. The rationale for this is that the national pension is non-linear, which makes microsimulation a superior modeling approach. It is particularly difficult to capture the impact of immigration in a semi-aggregated model.

Various other quantities are also compared when updating the models to a newer version. Typically, changes are made to the ELSI model if outcomes between the two models differ significantly.

When simulating years that have already passed, some parts of the ELSI model are also aligned directly to Finnish Centre for Pensions statistics. An example is provided by the modeling of the amount of pension accrued from periods of receiving social security benefits and other unsalaried periods, where parameters are adjusted in such a way that on the aggregate level these pension accruals match the statistics.

Model applications

The results of the ELSI model are reported regularly as part of the Finnish Centre for Pensions' long-term projections. The model is also used when analyzing the effects that various policy proposals would have on pension benefits. In the future the model will also be used to analyze the retirement incentives for those who have exceeded the lowest age of eligibility for old age pension.

In the following section, we demonstrate how the model has been used in the past and how it could be used in the future.

Long-term projections

The ELSI model is used on a regular basis for producing information on pension distributions and pension levels for population subgroups as part of the Finnish Centre for Pensions' long-term projections. Regular updates of the model are scheduled so that a new version is available for the long-term projections. The latest projections are available in Tikanmäki et al. 2019.

These projections contain information on median monthly pensions by sex and educational level. This data is presented in Figures 2 and 3 in euros and in relation to the median wage in Figures 4 and 5.

Figure 2.
Median of pensions received in one's own right, by educational level, men (at 2017 prices, €/month)
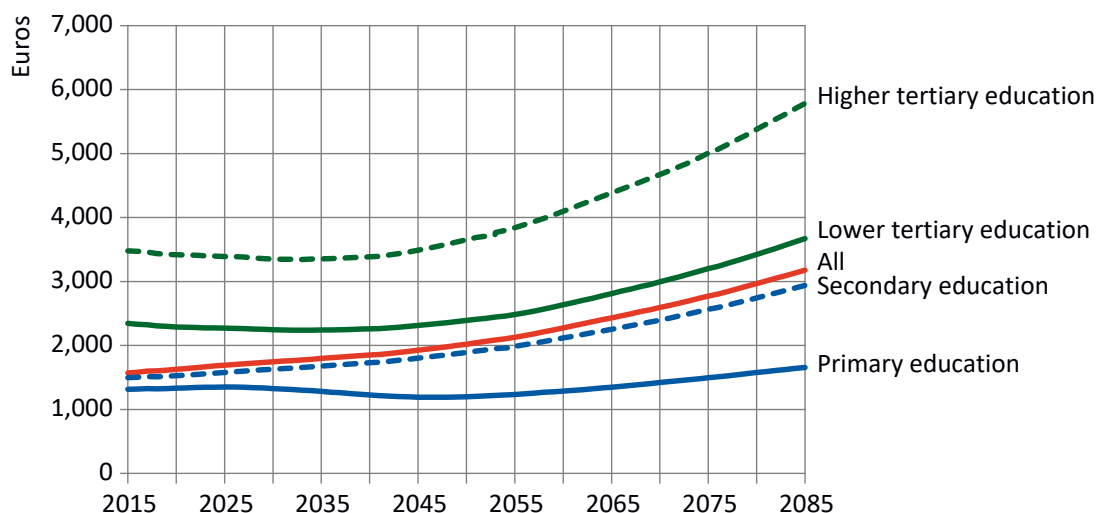
Figure 3.
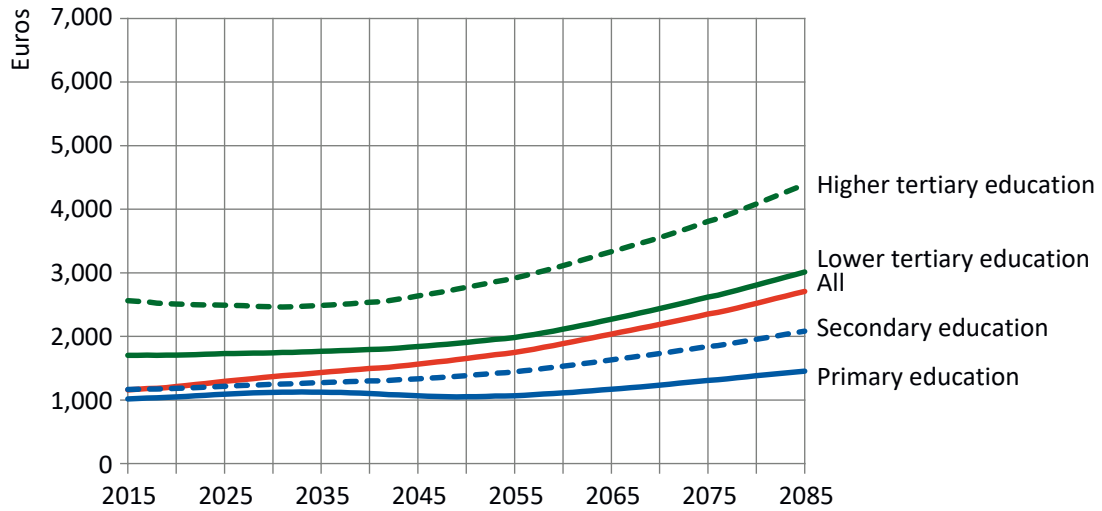Median pensions received in one's own right, by educational level, women (at 2017 prices, €/month)

Figure 4.
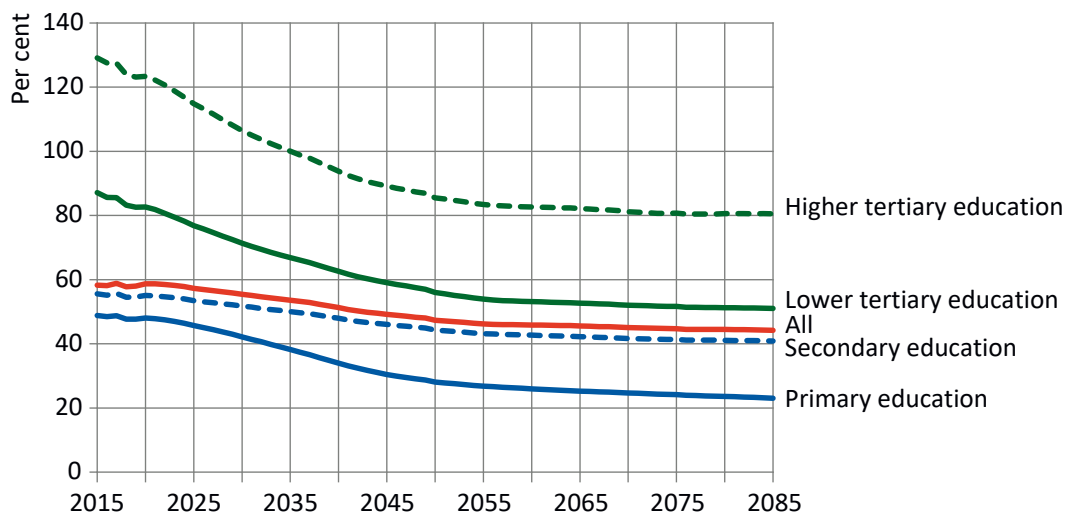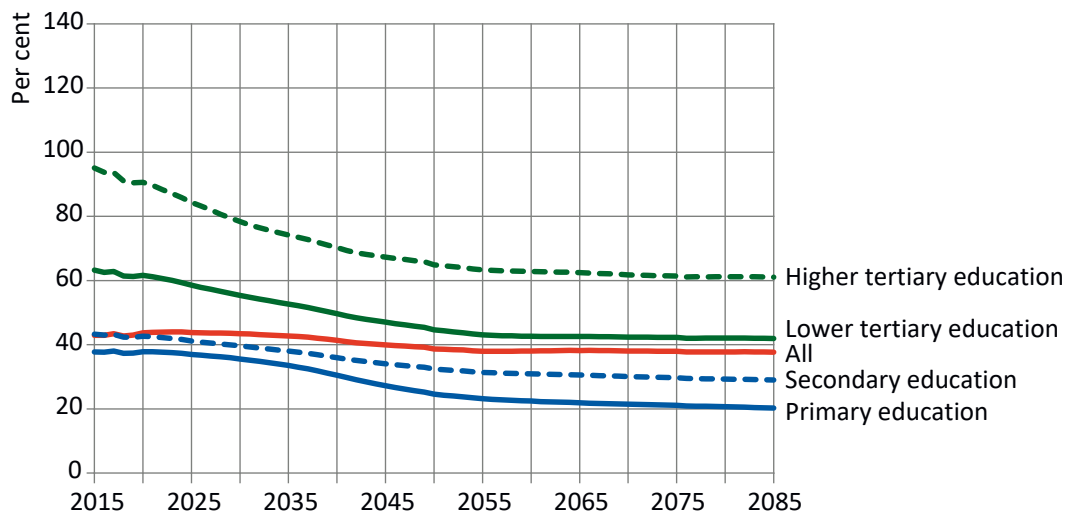Median pensions received in one's own right relative to median earnings, by educational level, men

Figure 5.
Median pensions received in one's own right relative to median earnings, by educational level, women

Tikanmäki et al. 2019 also contains information on pension distributions by sex. Below we present the 10th, 25th, 50th, 75th and 90th percentiles of the pension distribution for men (Figure 6) and women (Figure 7).

Figure 6.
Distribution of pensions received in one's own right, men (at 2017 prices, €/month)
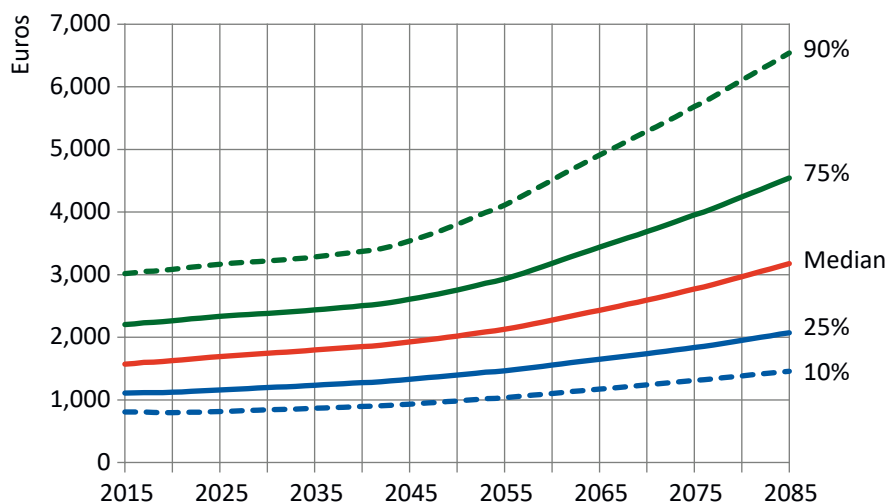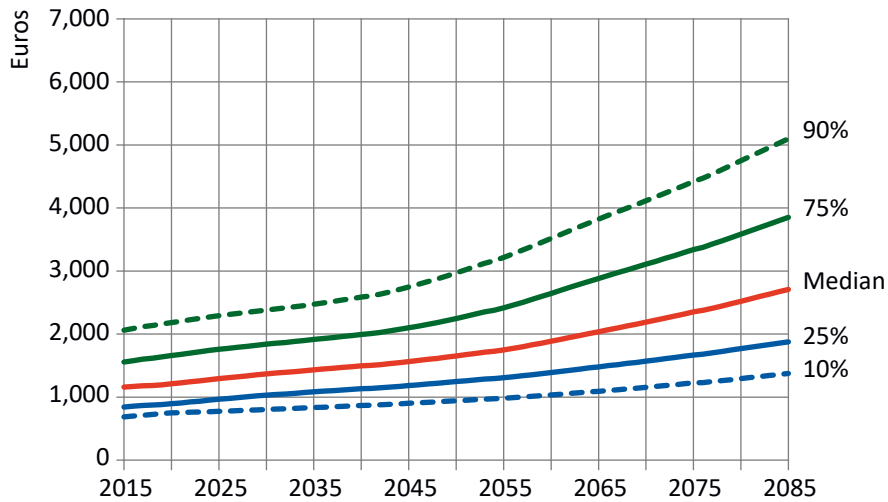
Figure 7.
Distribution of pensions received in one's own right, women (at 2017 prices, €/month)

The ELSI model outputs individual level data, so it is also possible to collect various other results. These include pension distributions for population subgroups, information on pensioners' gross and net income and various poverty and inequality measures. However, these results are not reported on a regular basis.

Policy analysis

One of the main uses of the ELSI model is to analyze how various policy options affect pension benefits. The model has been used to analyze the impacts of the 2017 pension reform on the length of working life, on pension distributions and on the pension levels of people at different educational levels (Tikanmäki et al. 2015a and 2015b).

Furthermore, the model has been used to analyze the effects that various indexing proposals would have on pension distributions. However, these analyses are not publicly available.

The model has also been used in a scenario analysis to examine how changes in the nature of work would impact the outlook for the pension system. To be more precise, we have analyzed how a sharp increase in wage inequality would affect future pension distributions (Tikanmäki et al. 2017a).

The ELSI model supplements the Finnish Centre for Pensions' LTP model. It is used for policy analysis purposes when information is needed on income or pension distributions. The earnings-related pension in Finland is linearly based on career earnings and hence in most cases the LTP model is the most suitable tool for analyzing the costs of policy proposals.

National and guarantee pensions are non-linear with regard to earnings and therefore the microsimulation approach is more appropriate. For purposes of assessing short-

term implications, it is also possible to use the SISU model (Statistics Finland 2019). But as far as long-term impacts are concerned, ELSI is the superior tool.

There have been some proposals for the inclusion of non-linear elements such as pension ceilings or complex indexing rules in earnings-related pensions. ELSI is the most natural tool for analyzing the impacts of these kinds of changes.

It is also notable that linear changes to earnings-related pension rules may have different impacts for different subgroups. Microsimulation is a natural tool for studying a priori how these subgroups would be affected.

Retirement incentive analysis

Even though ELSI does not use behavioral equations and economic incentives to simulate individual decisions, the model can be used for calculating the economic incentives for retirement decisions. For such an analysis, it was necessary to make some modifications to the model. A new module was built between the earnings module and the earnings-related pensions module. In addition, notable changes were made to the population and results modules.

The idea is that the analysis of retirement incentives only considers those individuals who are working at the earliest age of eligibility for old-age pension. In practice the transition probabilities at the late stage of working life are manipulated so that these people continue to work until they reach the highest possible retirement age[6] (unless they die before that age), i.e. 68–70 years depending on the birth cohort. These modifications are done in the population module.

Next, we calculate recursively the pension for all possible retirement ages in one-year time steps. For this we need to run the data through the additional module built for this specific purpose as well as through the earnings-related pension module and the national pension module.

Finally, we compare the rest-of-life earnings for different retirement ages. Future annual monetary amounts are discounted to present value using a predefined real discount rate. Results can be obtained for these different income measures:

1. Earnings-related pension,
2. Total pension,
3. Gross income including pensions and wages, and
4. Net income.

Using the data produced in this manner, it is also possible to calculate other measures such as forward-looking participation tax rates (Brewer et al. 2012).

The structure of the modified model for retirement incentive analysis is shown in Figure 8. New or modified modules are shown on blue and other modules on white.

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6   To be more precise, the age at which the insurance obligation ends.

Figure 8.
Modified ELSI model structure for retirement incentive analysis.
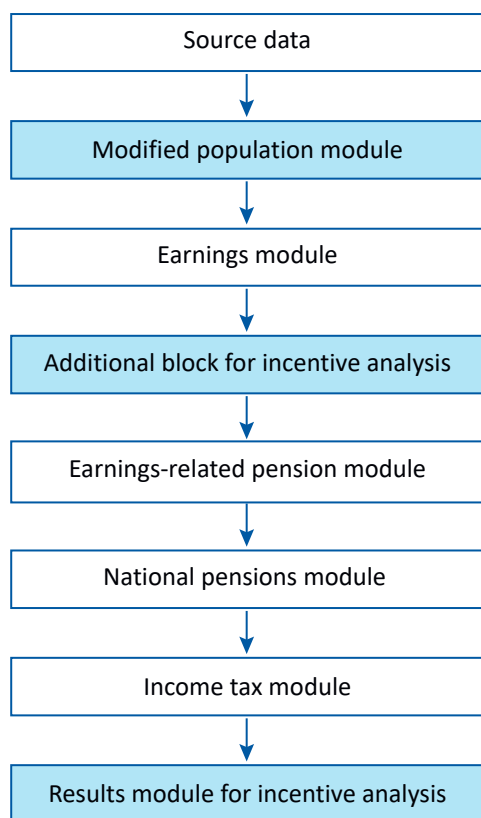
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APPENDICES

Appendix 1: Parameters of the dynamic wage process

Table 3.
Parameters of the dynamic wage process

k_1					
	primary	high school	vocational	lower tertiary	higher tertiary
men	0.059	0.295	0.135	0.004	0.394
women	0.205	0.121	0.107	0.14	0.142
k_2					
	primary	high school	vocational	lower tertiary	higher tertiary
men	0.011	0.062	0.031	-0.047	-0.023
women	0.031	-0.001	-0.025	-0.026	-0.033
T men					
	primary	high school	vocational	lower tertiary	higher tertiary
AK	0.288	-0.429	0.171	1.092	0.076
A1	0	0	0	0	1.293
A2	-0.047	0.1	0.23	0.382	0
others	0	0	0	0	0
T women					
	primary	high school	vocational	lower tertiary	higher tertiary
AK	-0.346	-0.029	0.281	0.336	0.407
A1	0	0	0.281	0.287	0.251
A2	-0.16	-0.582	0	0	0
others	0	0	0	0	0
K_1					
men	0.27				
women	0.31				
K_2					
men	0.5				
women	0.22				
sigma					
men	0.254				
women	0.3				
u					
	location	scale	asymmetry		
men	0	1.2	1		
women	0	2	1.6		

Figure 9.
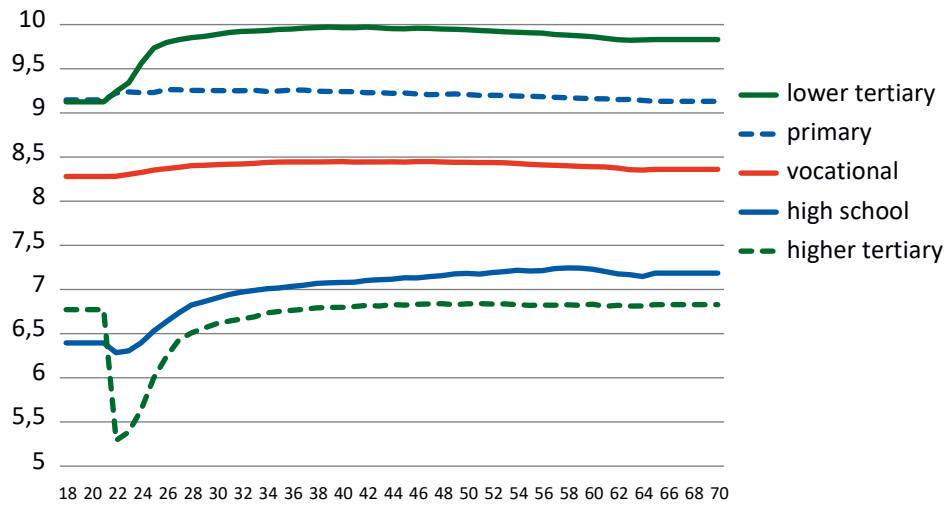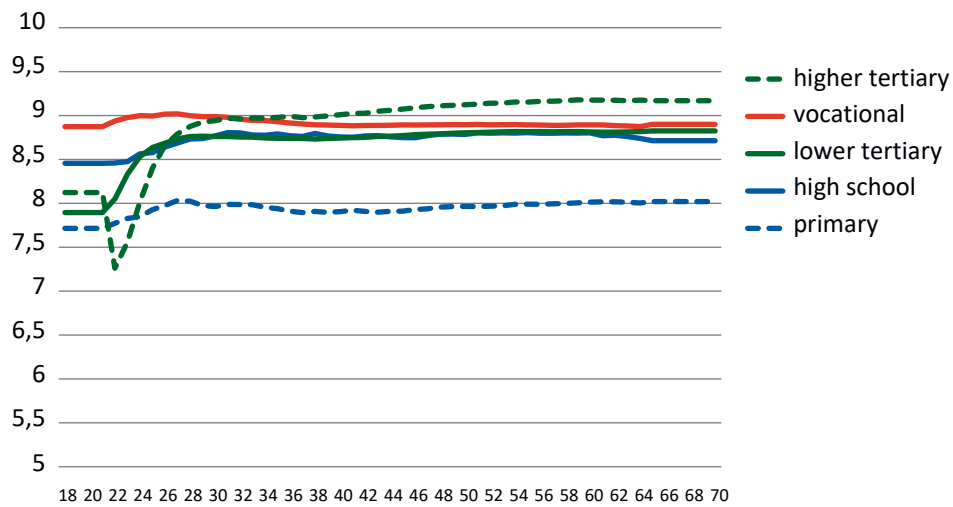Wage profile parameter P by age and education, men.

Figure 10.
Wage profile parameter P by age and education, women.

Appendix 2: Parameters of the static wage process

Table 4.
Parameters of the static wage process

$\tilde{K}_1$	0.3		
$\tilde{K}_2$	0.3		
sigma			
men	0.29		
women	0.33		
$\tilde{u}$			
	location	scale	asymmetry
men	0.35	1.45	0.9
women	0.34	2.4	0.95

Figure 11.
Wage profile parameter $\tilde{P}$ by age and education, men.
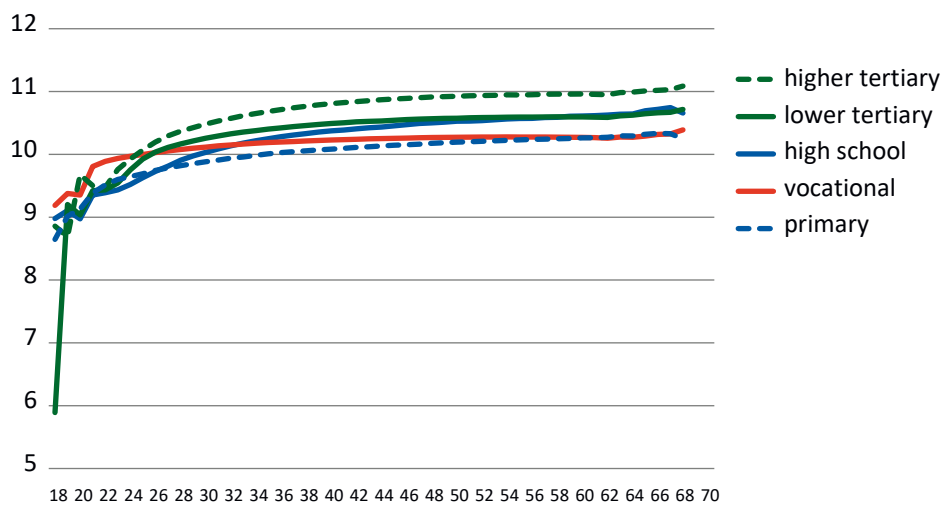
Figure 12.
Wage profile parameter $\tilde{P}$ by age and education, women.
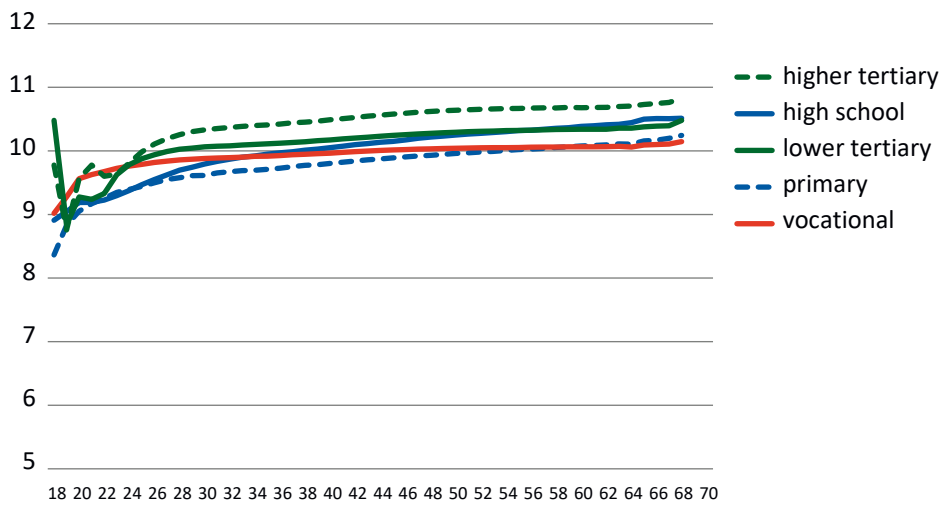
ELSI: The Finnish pension microsimulation model

This report is an overview of the structure and functionalities of the pension microsimulation model ELSI. Developed and maintained by the Finnish Centre for Pensions, ELSI is used to simulate the life courses of individuals in order to forecast the long-term development of Finnish earnings-related pensions and national and guarantee pensions.