Longevity risk

Microscopic population modelling

Introduction

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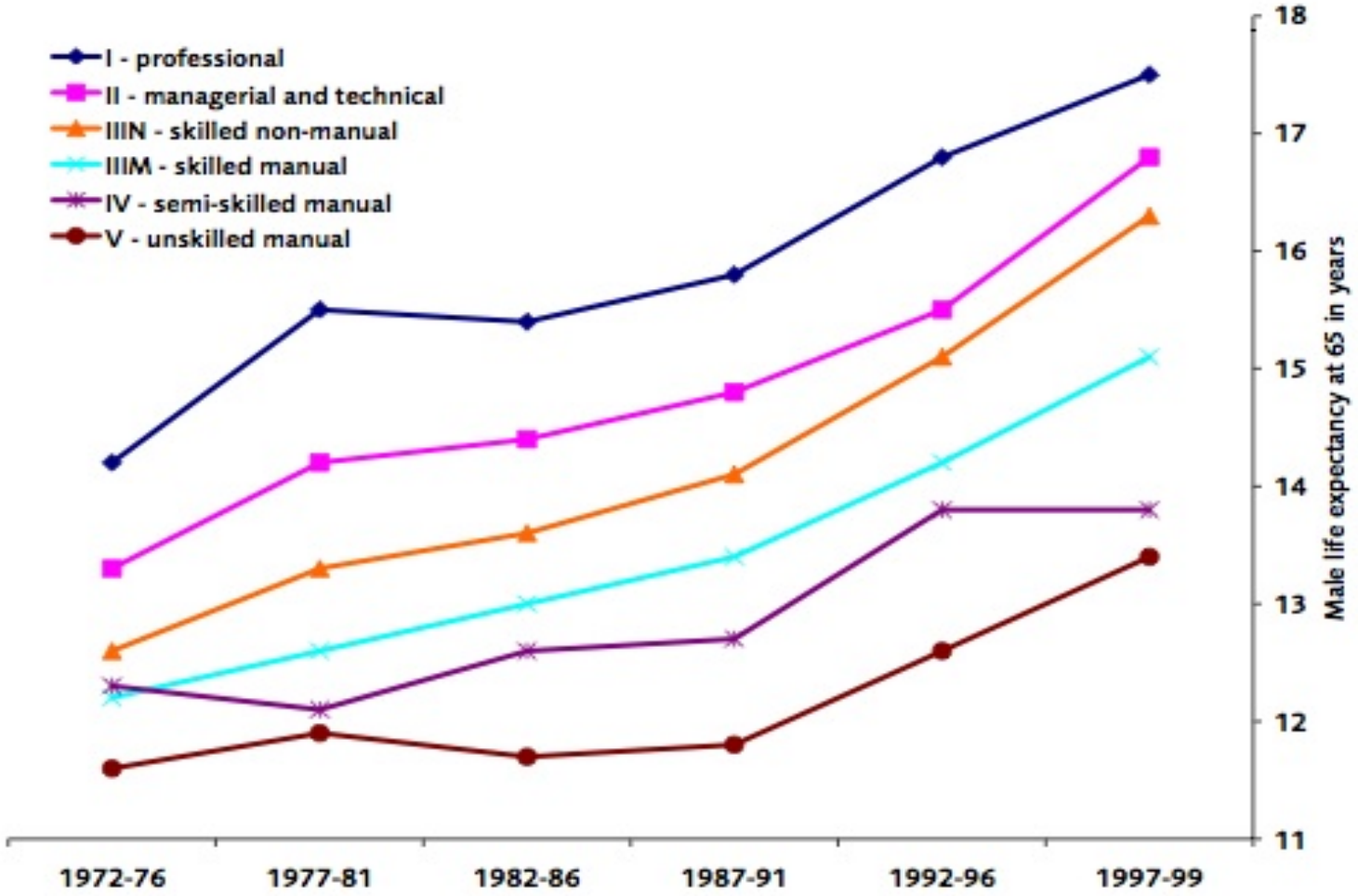
Plan

Heterogeneity

- Longevity patterns and longevity improvements are very different for different countries, and different geographic area.
- Factors affecting mortality
  - socio-economic level (occupation, income, education, wealth...)
  - gender
  - marital status
  - living environment (pollution, nutritional standards, hygienic...)

Male Life Expectancy from age 65

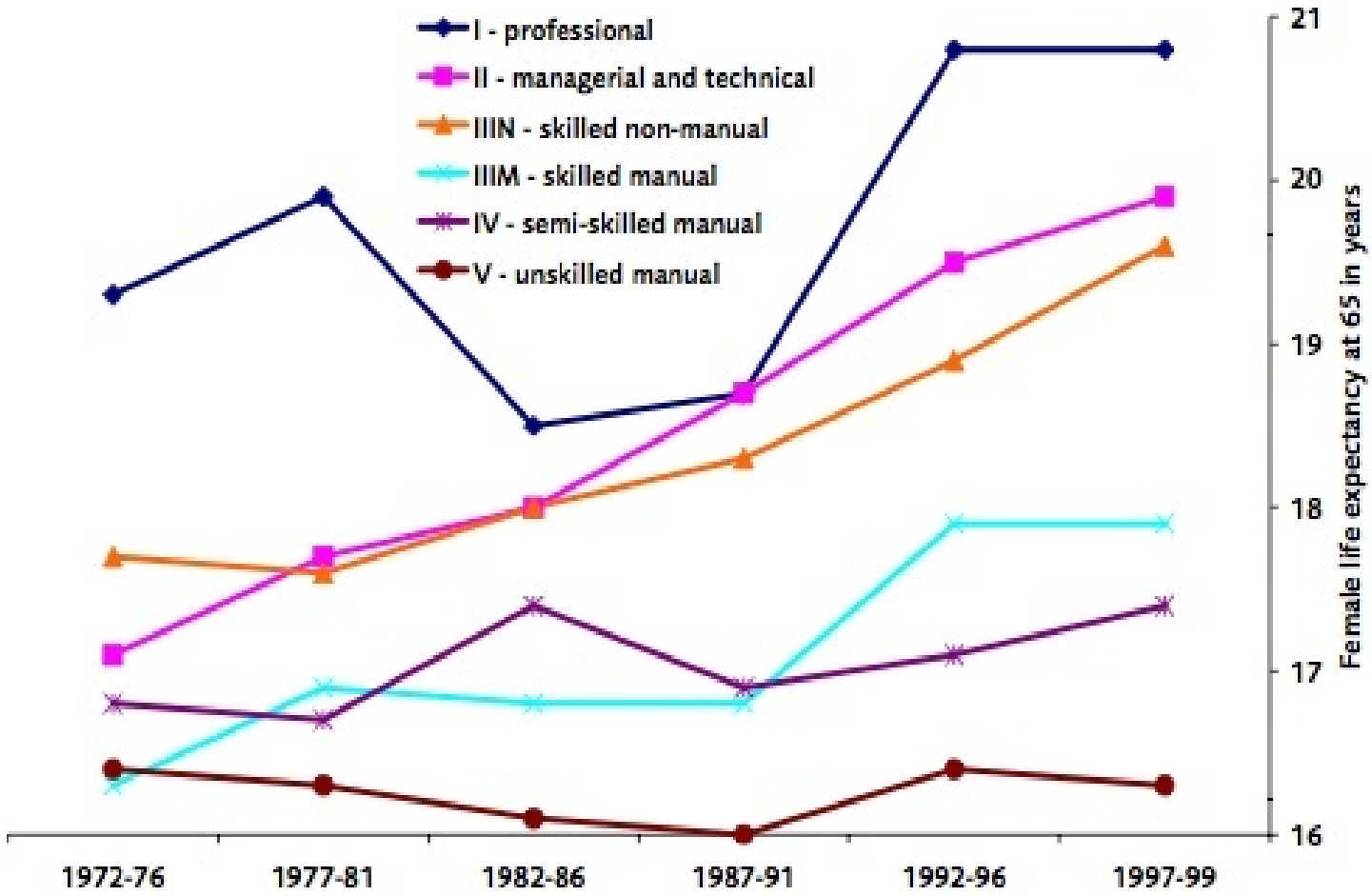
Figure 10. Male life expectancy from age 65 by socio-economic group



Source: ONS Longitudinal Survey.

Female Life Expectancy from age 65

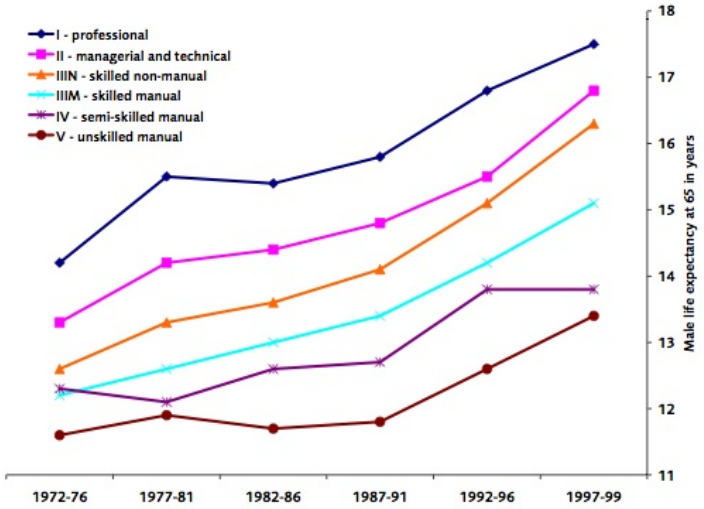
Figure 11. Female life expectancy from age 65 by socio-economic group



Source: ONS Longitudinal Survey.

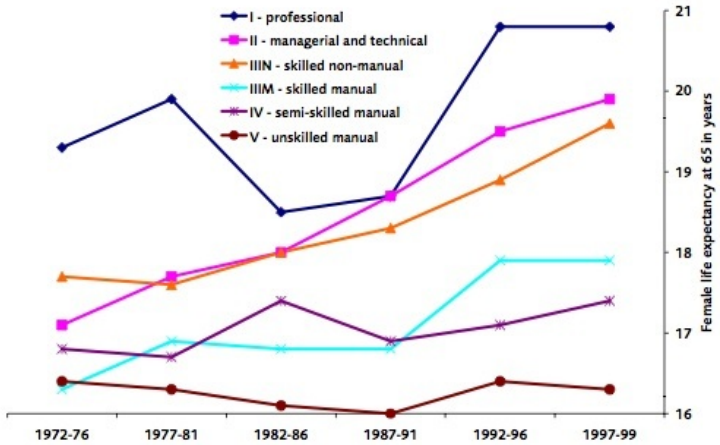
Social Heterogenity of Life Expectancy

Figure 10. Male life expectancy from age 65 by socio-economic group



Source: ONS Longitudinal Survey.

Figure 11. Female life expectancy from age 65 by socio-economic group



Source: ONS Longitudinal Survey.

Basis risk I

Difference : national mortality versus that of specific group

- Insurance companies can use national reliable mortality estimates on large samples
- but the final goal is to model mortality rates specific to subpopulations with owns traits
  - population of a small country or region,
  - individuals with a specific disease,
  - insurance portfolio,
  - annuitants of sectorial pension funds.
- But also how take into account other informations
  - They know the exact ages at death and not only the year of death (time continuous data)

Basis risk II

- Cause of death are specified
- Characteristics of the policyholders : socio economic level, living conditions ...
- selection bias

▶ BUT

- limited size of their portfolios (in comparison to national populations : 700 000 individuals from 19 different insurance companies)
- small range of the observation period

This heterogeneity is very important for longevity risk transfer based on national indices: for too important basis risk, the hedge would be too imperfect

Mortality by age and by trait

Determining factors

- Find individual characteristics (such as socio-economic level or income, educational level, postcode, marital status) that can explain mortality
- Take them into account in a stochastic mortality model

Conditional calibration

- On national mortality data and on specific data (with information on individual characteristics)
- In France, specific data=Permanent demographic sample=992711 persons, died only from 1967

AIM (H. Bensusan PhD Thesis) : Reduce the basis risk by estimating the deviation of the "individual mortality" from the general mean

Plan

Microsimulation

Dynamics Microsimulation : Used by INSEE (DESTINIE) and many agencies in Australia (DYNAMOD), Canada, US, ...

- I=The model
  - based on a micro data base of individuals of the national data base (30.000 or $+ \equiv 1\%$)
  - imput additional characteristics, as level of education, socio economic level, gender, marital status
- II= Simulation
  - The model takes these sample and simulates the events that occur in each individual's life, from 1990, by stepping month-by-month through time until 2070
  - As the individuals progress through life, they experience a range of life events, in line with French data about the probabilities simulated in the model

Implementation

- The life events include death, fertility, divorce, e(im)-migration, level of education, labour force changes. These characteristics are often called traits
- III= Estimation
  - the rate of death and birth are estimated via the CDB model.
  - macroeconomic factors are also introduced and reajusted year by year
- IV= Dynamic Impact
  - The model captures changes in demography and behaviour over time, such as an ageing population or changing fertility rates
  - Interesting for modelling the distribution of income and assets at different times, and testing the impact of public policies

Why a new model?

- IV= Drawbacks
  - Simulation very too time consuming
  - leading to use very simple models
- New Model = Same principle but
  - No systematic simulation on the all sample
  - based on random inspection at random times

Plan

Microscopic models in ecology

Microscopic probabilistic models in ecology:

- Modelling a population according to birth, death, and mutation at birth
- Random evolution of a population based on birth and death rates possibly different for each individual
- Population structured by traits (*i.e.* individual characteristics) (N. Fournier et S. Méléard 2004)
- Extension to age-structured populations (V. C. Tran 2006)
- Particle model easy to simulate

Observations are made only at jumps times of Poisson process and only concern one individual each time