Age Dynamics of Learned Societies and Other Fixed-Sized Populations

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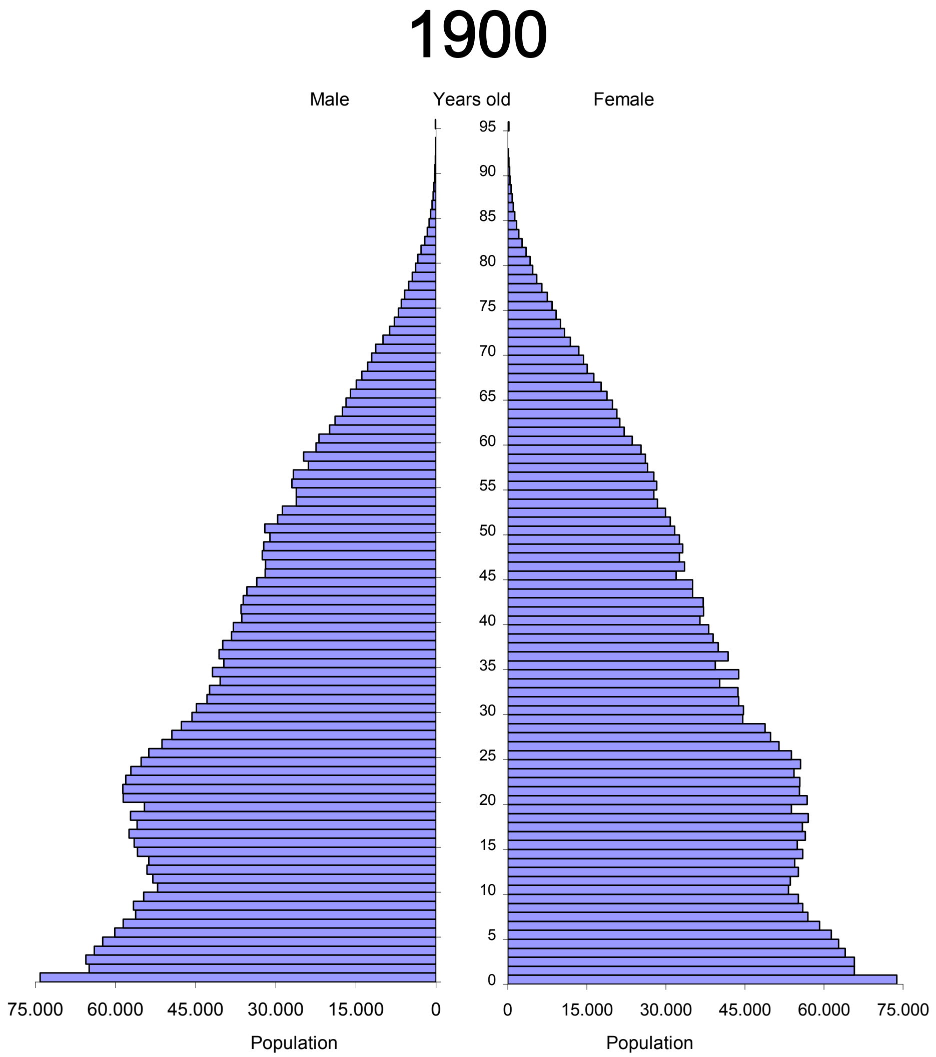
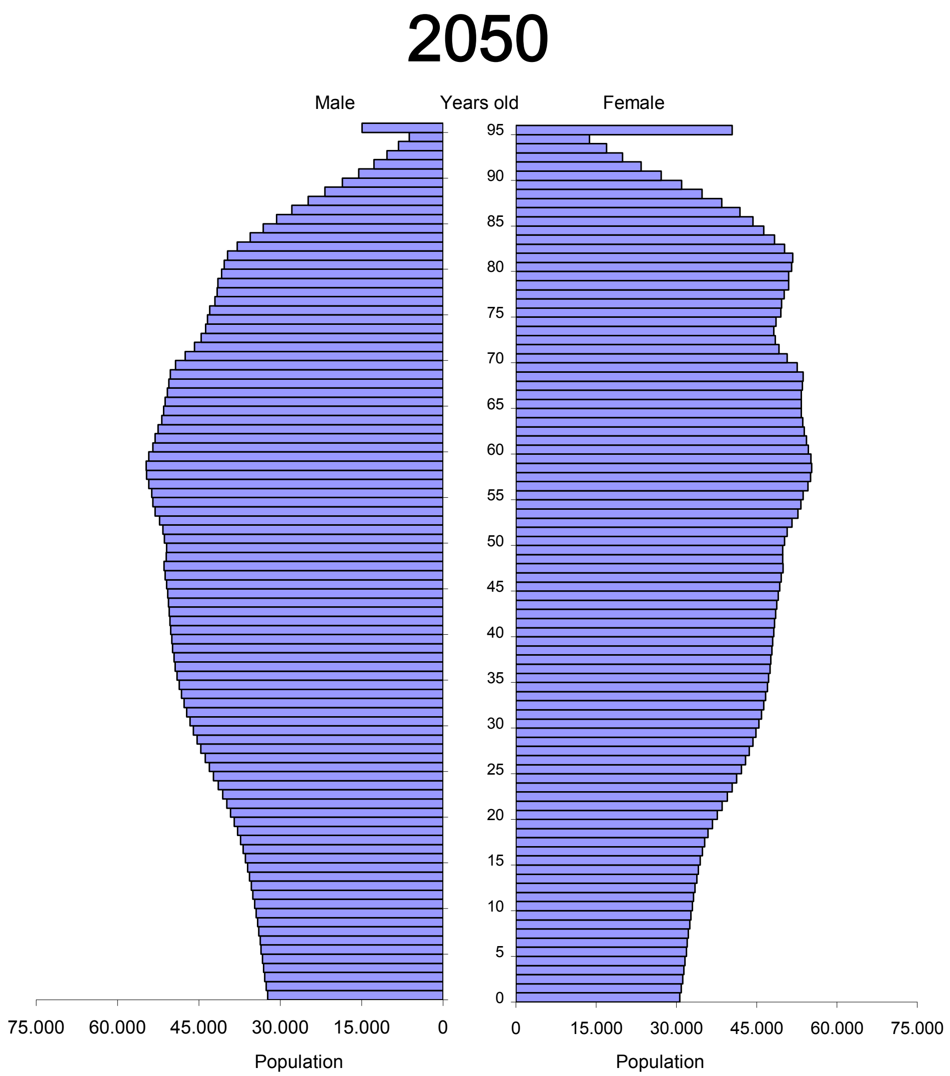
Structure

1. Motivation and intention
2. Demographic evolution of the Academy: 1847 - 2005
3. Mortality of Academy members
4. Projections
5. Optimal generation mix
6. Conclusions

Population pyramids for Austria (Source: Statistics Austria)



Population pyramid - projection (Source: Statistics Austria)



1. Motivation and intention

- Logic of population dynamics (Lotka; Euler, 1760)
- Population growth or ageing (Ryder, 1971)
- Progressive ageing of scientific institutions (Leridon, 2004)
- Projection of future trends
- Optimal composition of new entrants

2. Demographic evolution of the Academy: 1847 - 2005

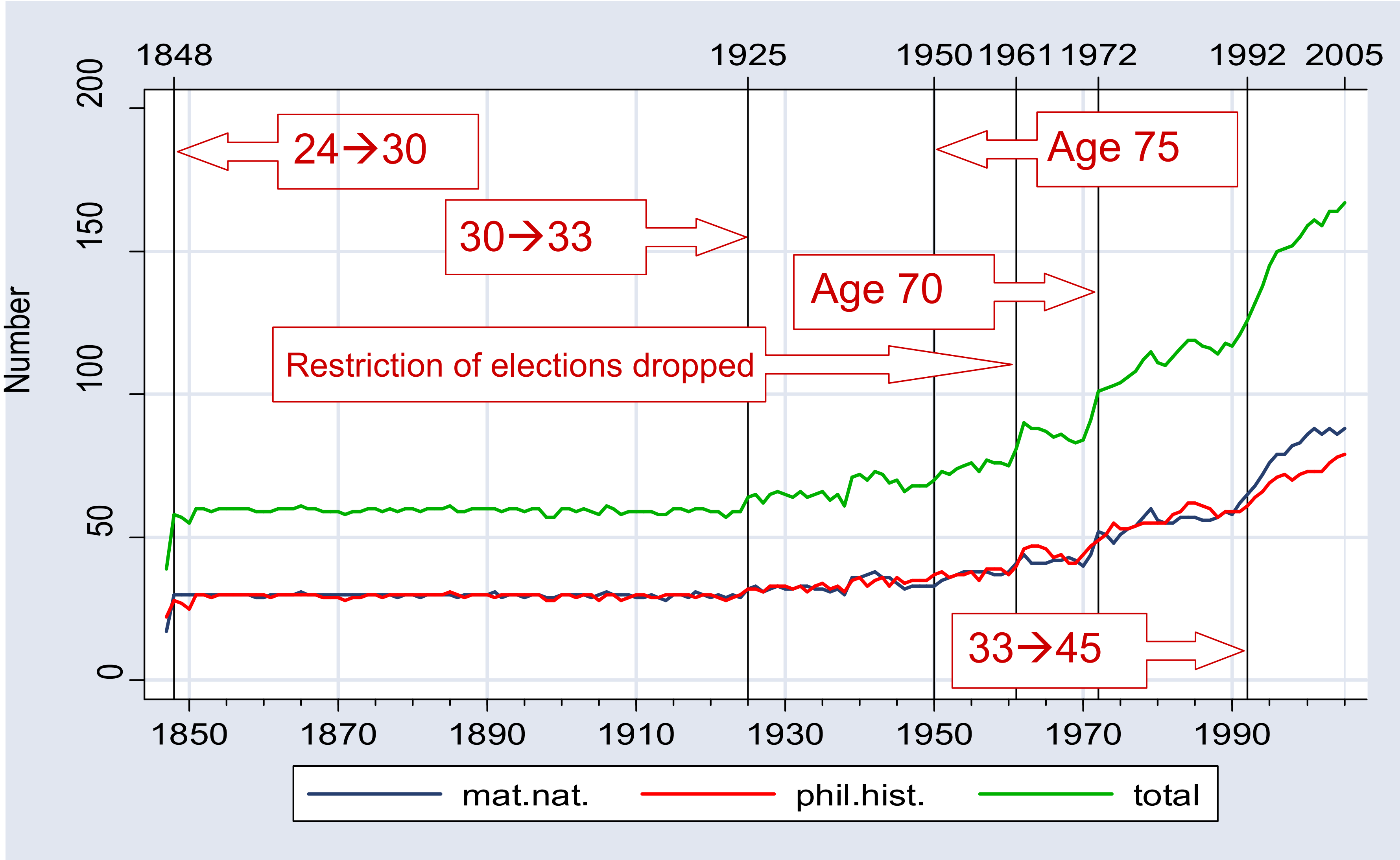
Biographical records (e.g. from Hittmair and Hunger, 1997)

- Date of birth and death
- Date of election
- Class affiliation
- Type of membership (full or corresponding member)
- Year of change in membership type (if applicable)

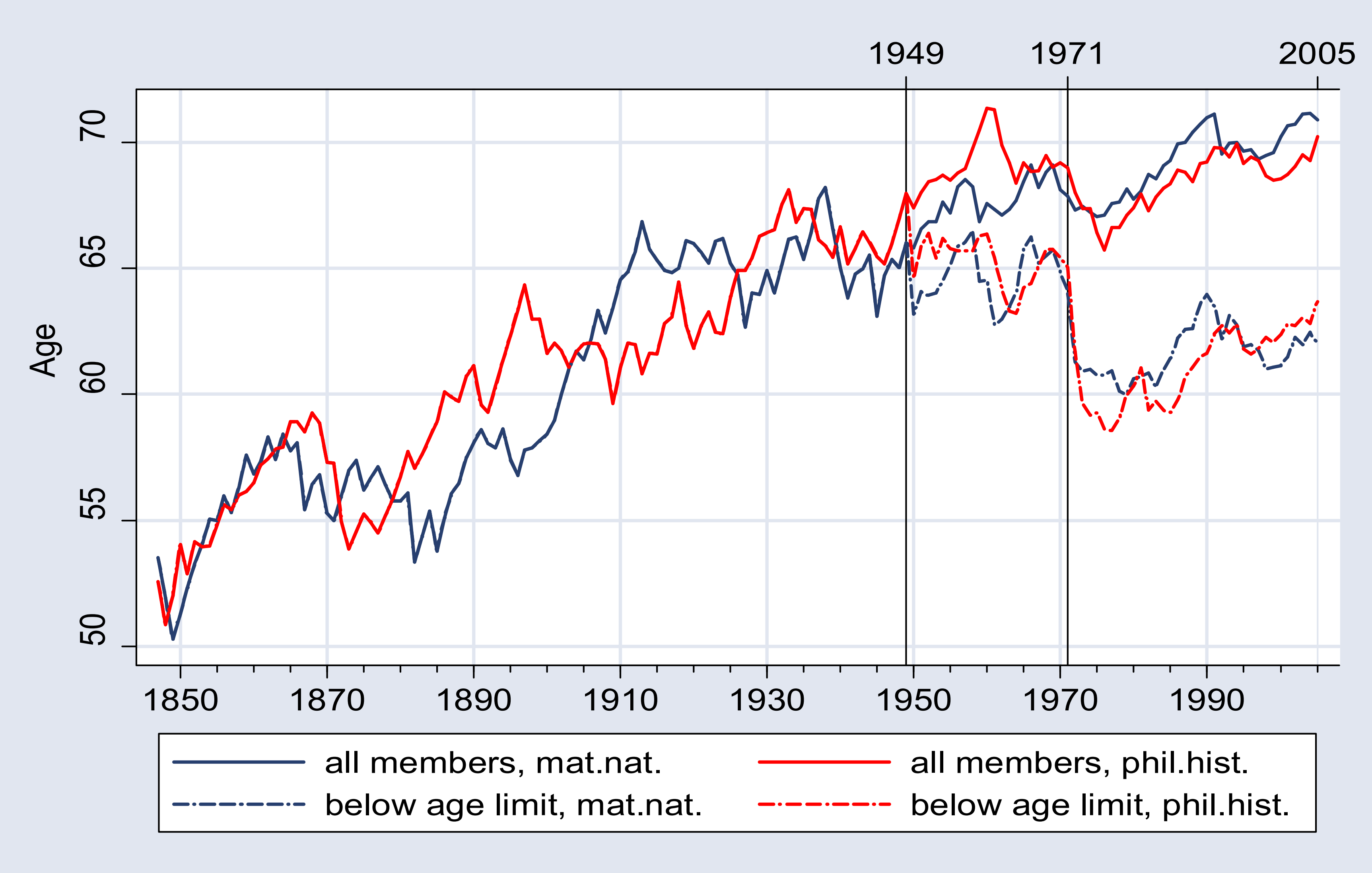
Numbers and pattern of members determined by

- Age distribution and numbers of new entrants
- Byelaws: numbers, age limits, ...
- Reduction through death or exit

Number of full members (annually)



Mean age of full members (annually)



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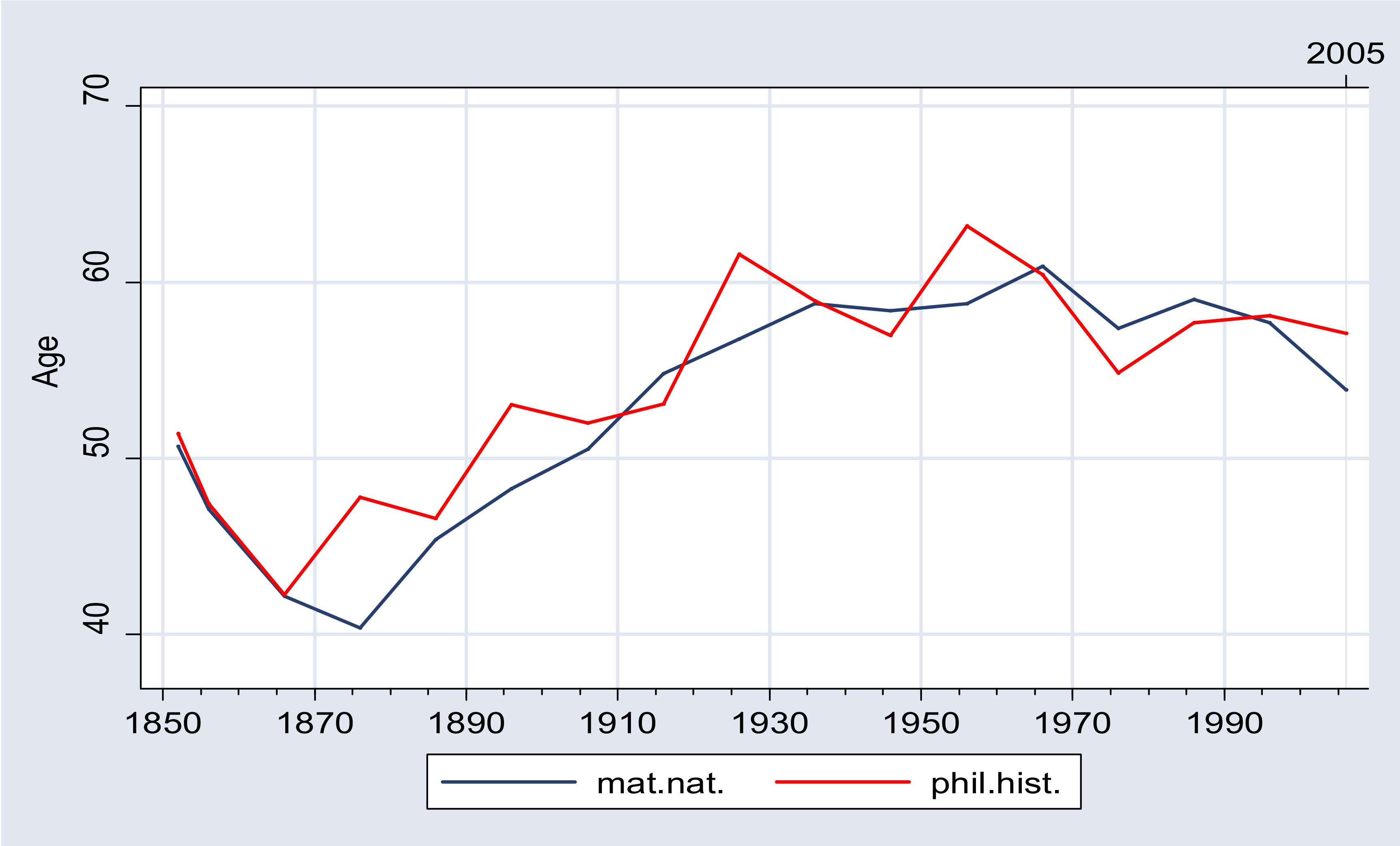
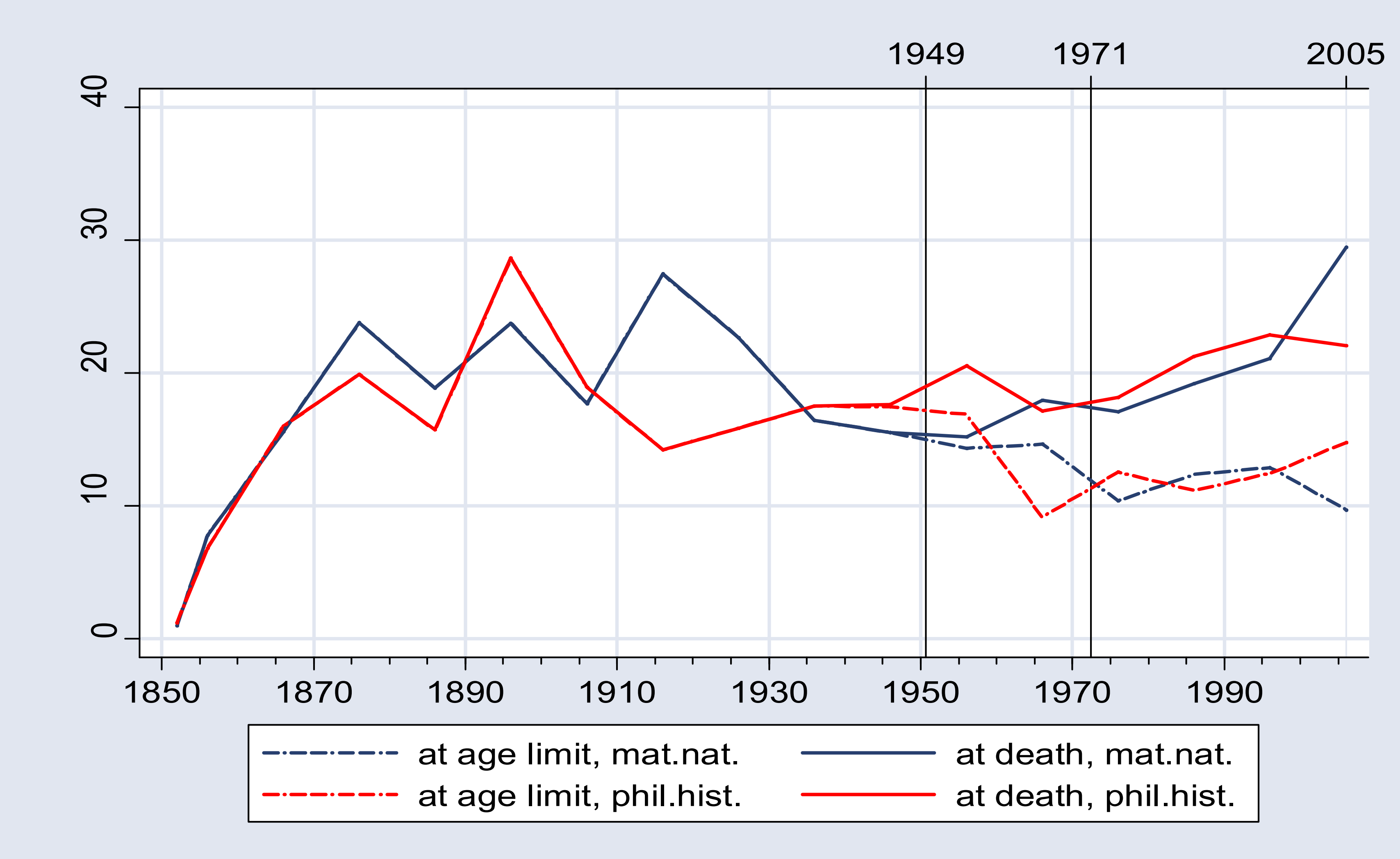
Mean age at election of full members
(10-year periods)



Mean tenure of full members
(at exit - 10-year intervals)



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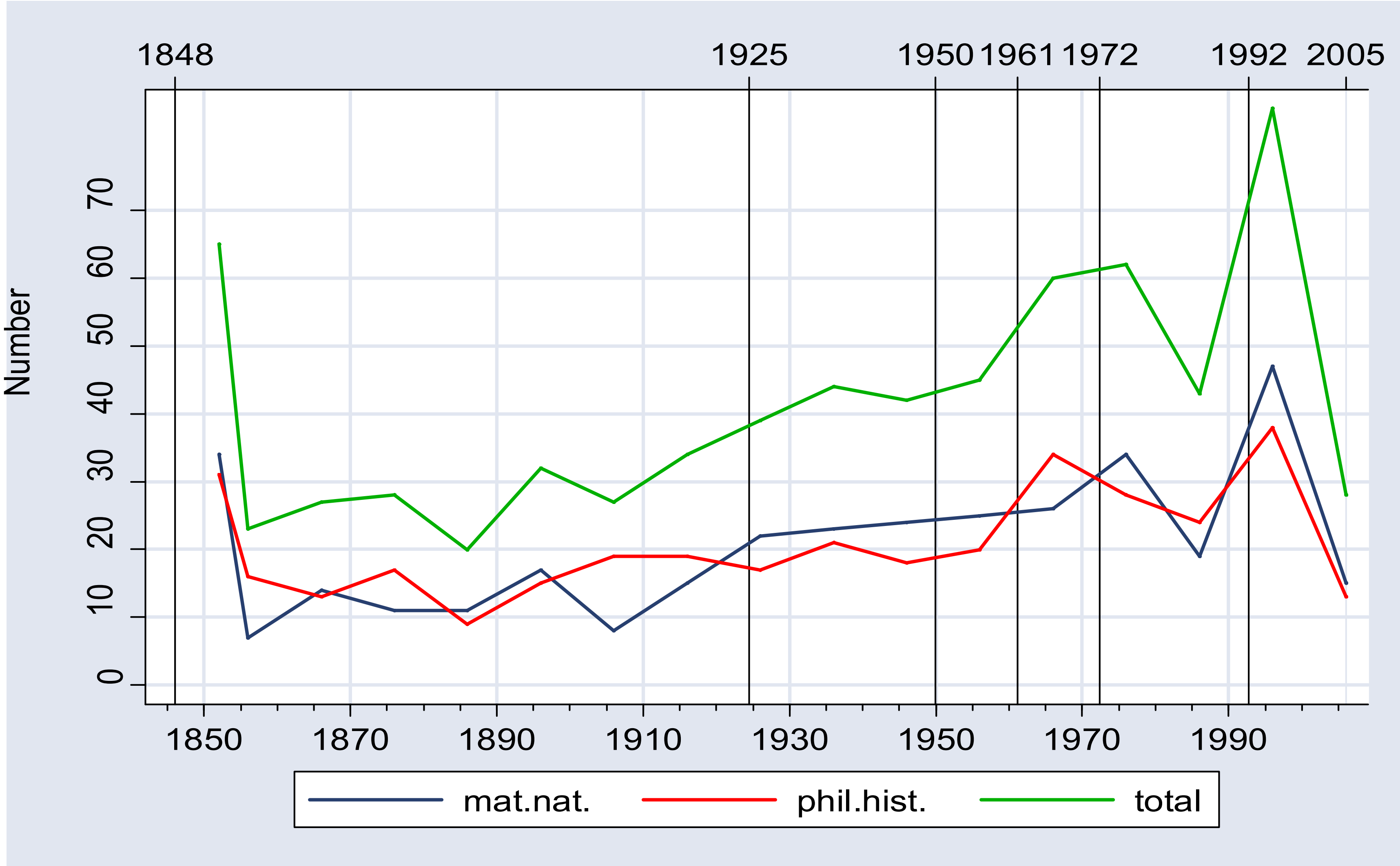
Number of new entrants

(10-year intervals)



Corresponding members

- Proportion of corresponding members ever becoming full members: ≈ 50%

- Mean ‘waiting time’: ≈ 7-8 years

3. Mortality of Academy members

	Academy members (1986/95)	Austrian male population (1991/92)	Austrian male population with tertiary education (1991/92)
Observed deaths at age 50 - 90	56		
Expected deaths at age 50 - 90		100.86	72.05
Standardised Mortality Ratio		0.56***	0.78*
Life expectancy at age 60	23.36	17.94	20.94

*** significant at 1%, ** significant at 5%, * significant at 10%

Health and life expectancy follow a 'social gradient'. Autonomy and lifestyle ('status syndrome') influence health and mortality.

(Marmot, 2004)

4. Projections

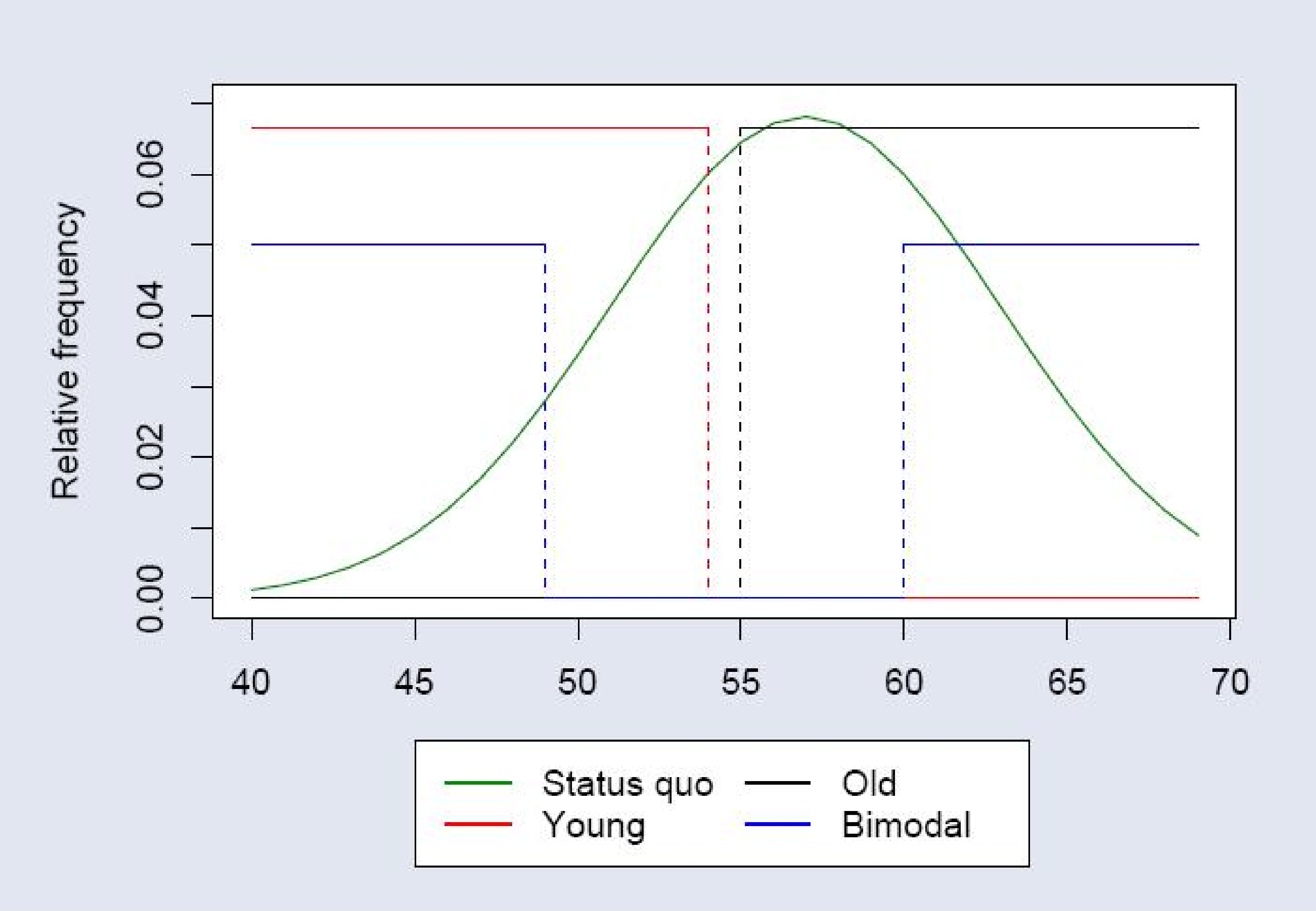
Future age distribution determined by

- Contemporary age structure
- Mortality development
- Age distribution of new entrants

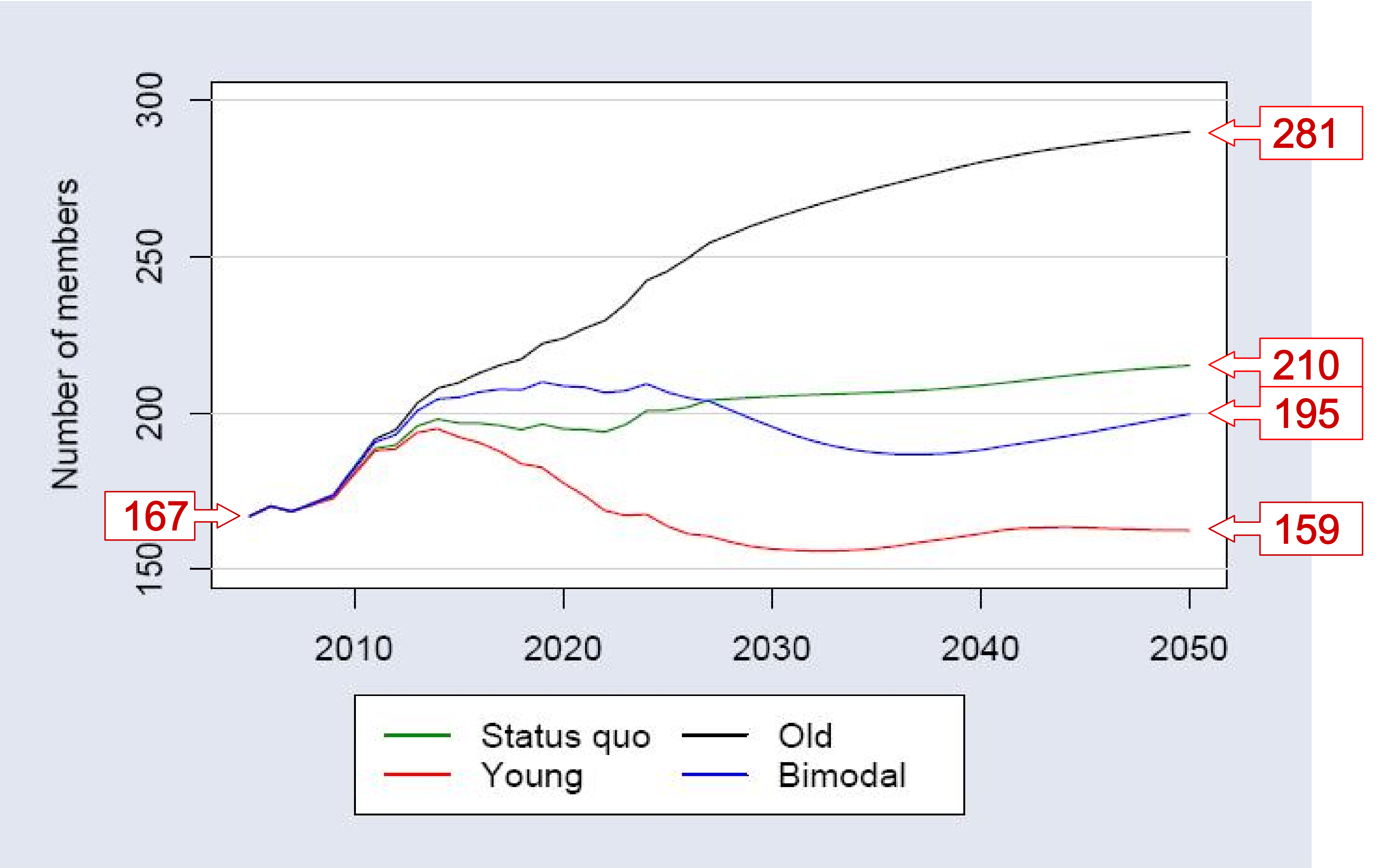
Number of vacant positions

- Number of members above age limit (70 years) plus deaths

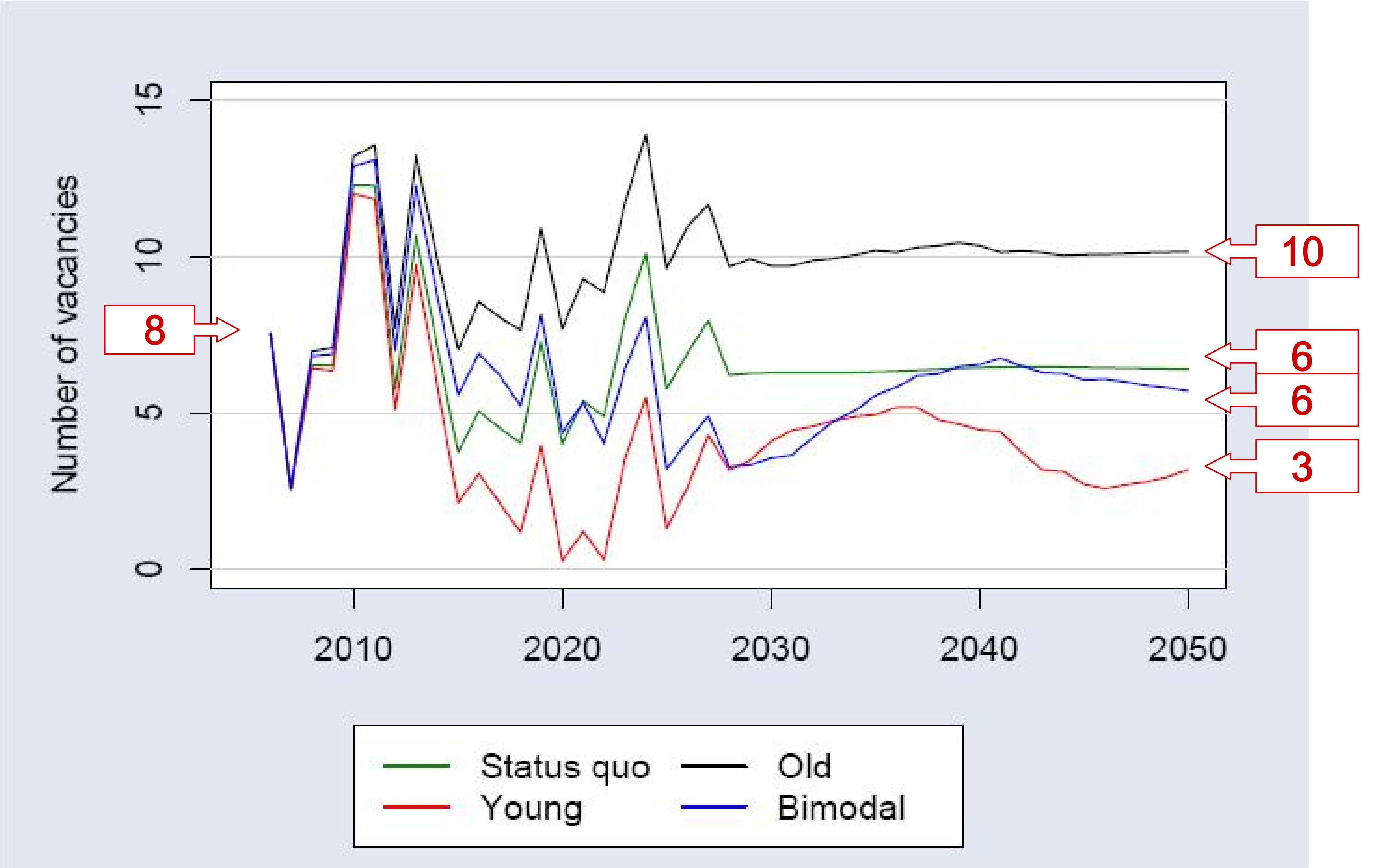
Scenarios


Relative frequency
0.00
0.02
0.04
0.06
40
45
50
55
60
65
70
Status quo
Old
Young
Bimodal

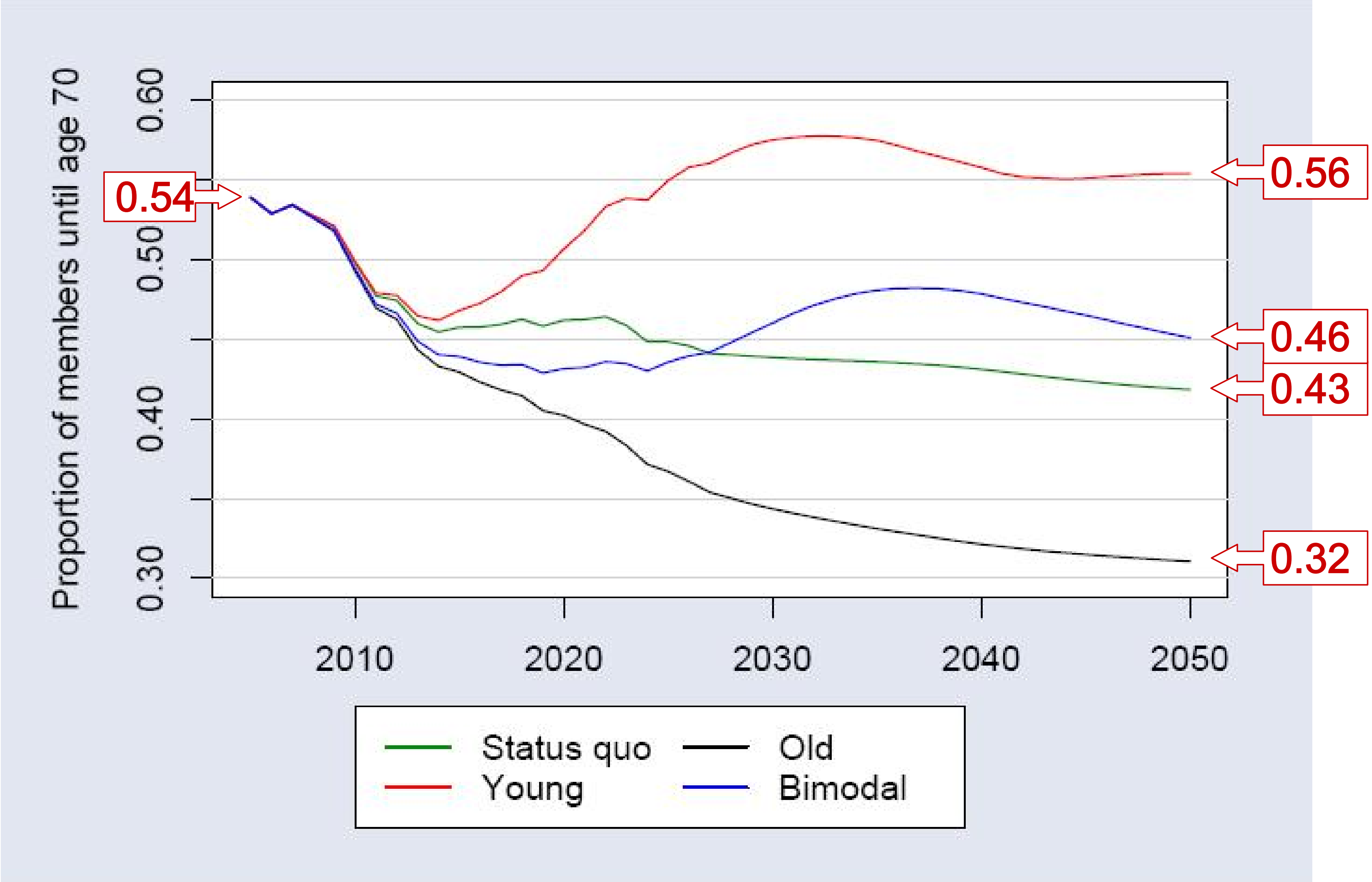
Number of full members



Number of vacant positions



Proportion of full members below age limit



5. Optimal generation mix

2 conflicting goals:

1. Recruit as **many** as possible of excellent researchers
2. Keep age structure of Academy **young**

Leridon (2004): „*To counteract the spontaneous trends in ageing in the institution new members would have to be elected at increasingly young ages year after year, which would have the drawback of reducing the rate of population replacement*."

Fundamental identity of a stationary population:

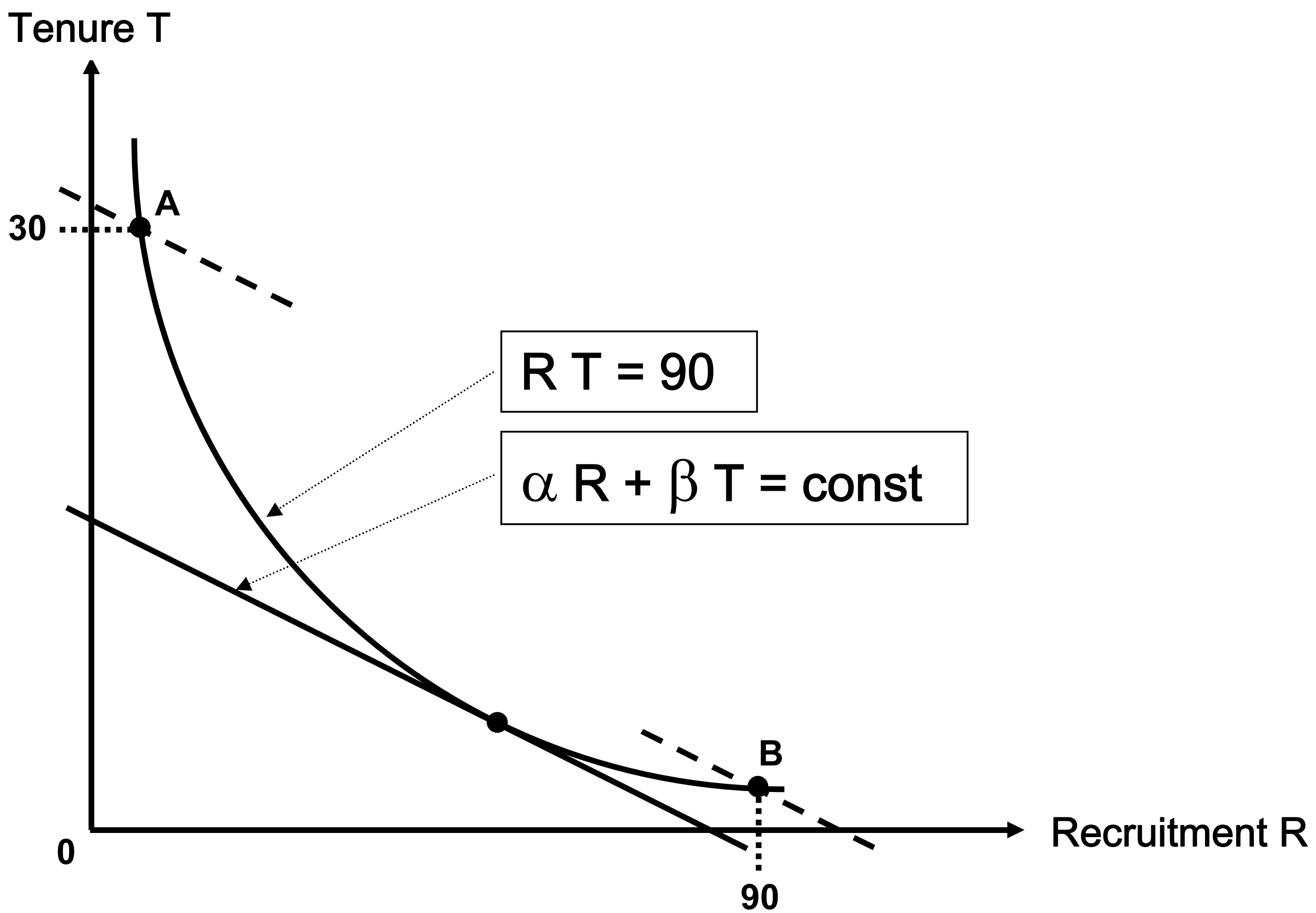
$$M = R\,T$$

M … total size of Academy (M=90)
R … number of annual new entrants
T … mean tenure (0<T<30)

Trade-off between recruitment R and mean tenure T:

$$\alpha R + \beta T \longrightarrow \max$$

Graphical illustration



Optimal generation mix

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$$\max_{u(t,a)} \int_0^\infty e^{-\rho t}[\alpha R(t) - \beta \bar{A}(t)]dt$$

$$M_t + M_a = -\mu(t,a)M(t,a) + R(t)u(t,a),$$

$$M(0,a) = M_0(a), \quad M(t,0) = 0,$$

$$R(t) = M(t,70) + \int_{40}^{70} \mu(t,a)M(t,a)da,$$

$$0 \le u(t,a) \le \bar{u}(a), \quad \int_{40}^{70} u(t,a)da = 1.$$

$M(a,t)$ - number of full members

$\bar{A}(t)$ - mean age

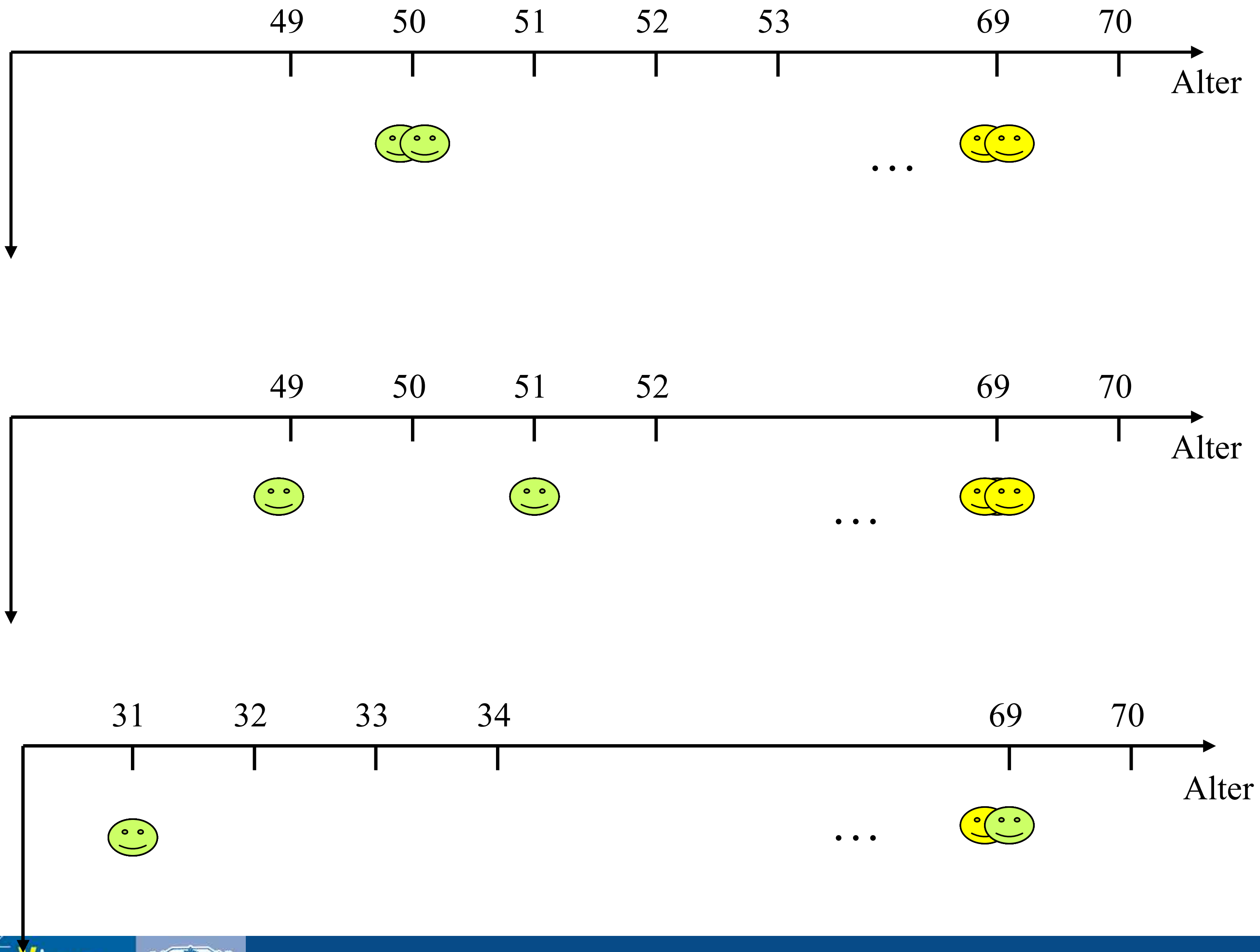
$R(t)$ - number of vacant positions

$\mu(t,a)$ - mortality

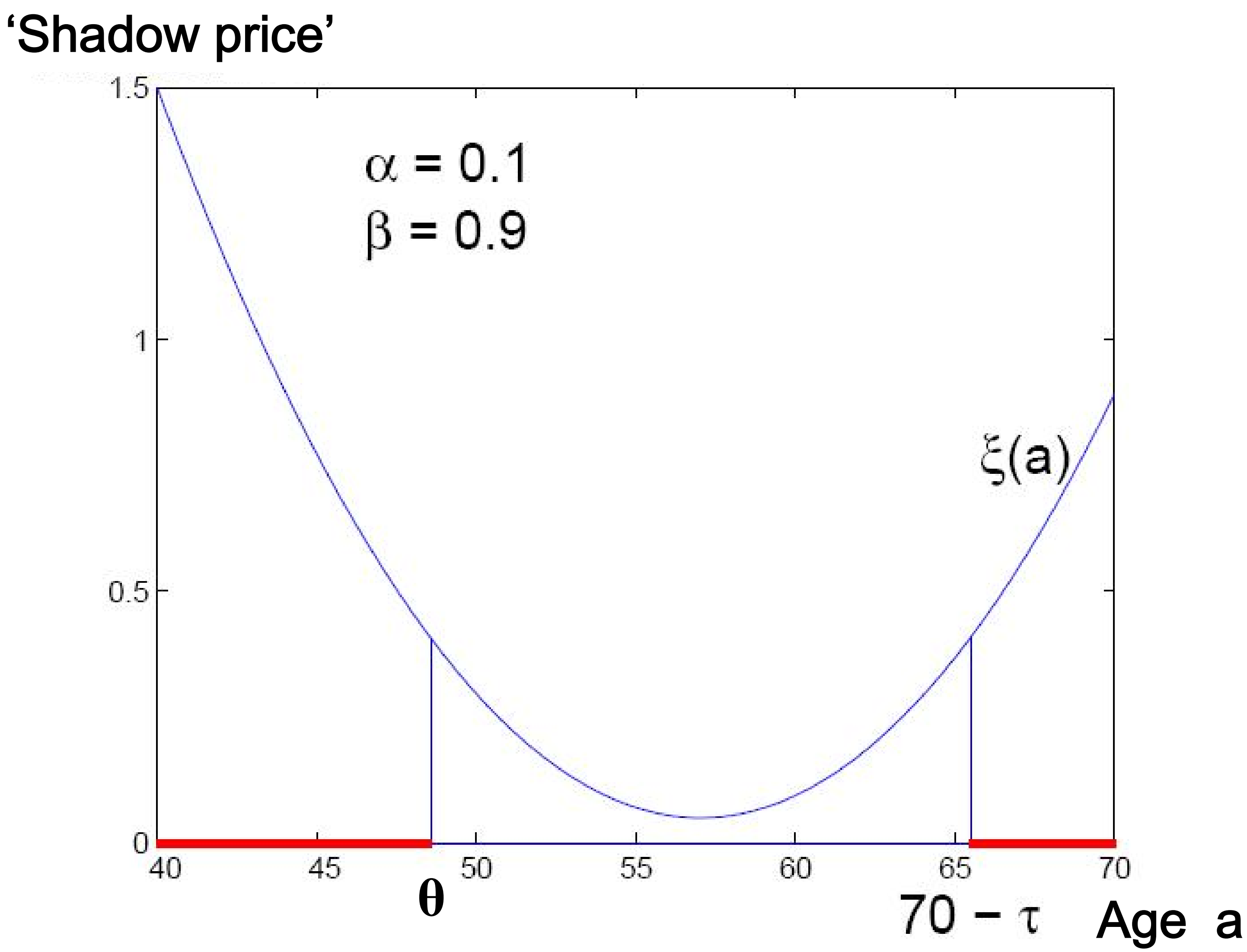
$u(t,a)$ - age distribution of new entrants

α, β - weights

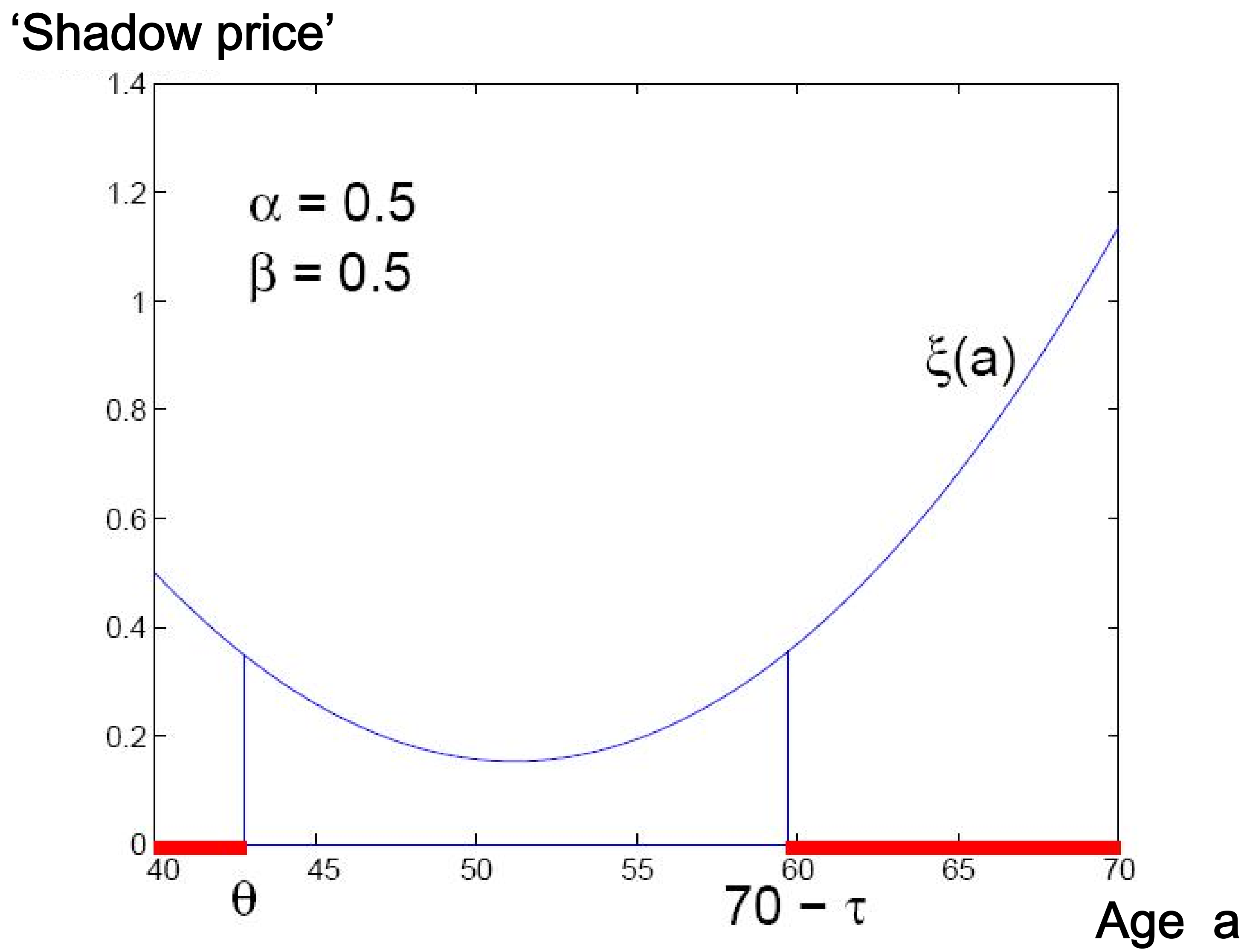
ρ - discount rate


49 50 51 52 53 69 70
Alter
...
49 50 51 52 69 70
Alter
...
31 32 33 34 69 70
Alter
...

‘Shadow price’ $\xi(a)$ of a member



'Shadow price' ξ(a) of a member



- Alternative objectives: productivity of members of organizations (publications, patents, organisational efforts)

- Minimizing the deviations from a given age-structure, from a given ratio of young to old members etc. Retirement age as control variable

6. Conclusions

- Historic development:
  Ageing due to rising life expectancy as well as higher age of new entrants

- Academy members have a higher life expectancy

- Projections:
  Impact of different changes on age structure and new entrants

- Optimal generation mix
  (**www.eos.tuwien.ac.at/OR/research/reports/RR297.pdf**)

Conclusions

- ‘Prospective Age’
- Application in personnel planning and migration research
- Comparative study of age dynamics of several Academies (A, B ,F, GB, I, NL)
- Demography for decision support:
  Impact of different assumptions on future paths

Age Structured Populations with Fixed Size

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A research project of the Vienna Institute of Demography
and the Austrian Science Foundation

Preston‘s (1970) **‚inverse‘ problem** of **population dynamics**, given time-invariant mortality, zero net migration and P(t). What is the **birth trajectory** generating P(t)?

Vaupel (1981) Trade-off between timing and intensity of promotion in compatment models

ALAK: Leridon (2004)

Historic, present and future development of the AAS (OeAW)

Feichtinger et al. (2006)

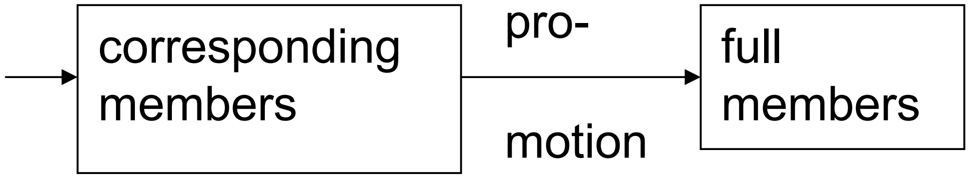
- Trade-off between a young age Structure and a high recruitment rate

- Bi-model optimal recruitment policy is optimal: Awarding young talents for outstanding achievements and older scientists for their life-long contributions (Sanderson)

- Alternative objectives: productivity of members of organizations (publications, patents, organisational efforts)

- Minimizing the deviations from a given age-structure, from a given ratio of young to old members etc. Retirement age as control variable

- Two-stage model



Trade-off between timing and quantum

Optimal election policies w.r.t.
(i) young age structure/high productivity of FM

(ii) number of elected FM per year

(iii) number of elected CM per year

(iv) average tenure of CM/chance to become FM

(v) mean age of CM

age-and duration dependent systems

cascade of 2 problems:

FM: (i) & (ii)   CM: (iii), (iv), (v)

CM system is duration-dependent, possible exits from CM not only by death and retirement, but also promotion from CM to FM.

Markovian person-flow models in manpower planning

Gani-type vs Young-Almond models

Bartholomew (1982, Chap. 3)

Keyfitz (1973, 1977): dependence of the age of promotion on the growth-rate of population

Henry (1971, 1973, 1975): career prospects dependence on the fluctuations in the rate of intake

Migration

Espenhade et al. (1982): below replacement fertility population with substained immigration long-run stationary

Arthur & Espenshade (1988), Mitra (1990): how does the ultimate population size & age distribution respond to variation in immigrant‘s ages

Feichtinger & Steinmann (1992): long-run stationary age distribution of natives and foreign-born persons

Schmertman (1992): does immigration like fertility act as rejuvenating force? Stationary populations via immigration … higher % of old, but lower % of young.

Wu & Li (2003): immigrants around age 20 minimize overall dependency ratio

Optimal Allocation and Timing in Life-Cycle Models

Feichtinger, Fürnkranz-Prskawetz, Kuhn, Wrzaczek

Ben-Porath (1967): the production of human capital and the life cycle of earnings

Burbidge & Robb (1980): optimal retirement and pensions: 2-stage models

Lee & Goldstein (2003): rescaling the life cycle

Bloom et al. (2007): optimal retirement as result of decling health

Kuhn et al. (2007): demand for health and the value of statistical life

Evolutionary demography

Baudisch (2008): optimal allocation between growth and reproduction in life-history models

Kageyama (2009)

Kaplan & Robson (2009)

Interdependence of micro and macro models (individual life cycle and social policy)

Vintage models: capital accumulation and population growth: distributed parameter control, anticipation effects

Multi-stage models: optimal switching time

Resume: Optimization is relevant in several fields of demography