Forecasting the age structure of the scientific workforce in Australia

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Labour force model

$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + G_{i,x,t} + E_{i,x,t}$$

i = Discipline x = Age t = Year

$P_{i,x,t}$ = number of equivalent full-time workers

$D_{i,x,t}$ = number of deaths $\sim$ Binomial($P_{i,x,t}, q_{x,t}$)

$R_{i,x,t}$ = number of retirements $\sim$ Binomial($P_{i,x,t} - D_{i,x,t}, r_x$)

$G_{i,x,t} = g_x G_{i,t}$ = number of graduates who work in discipline i

$E_{i,x,t}$ = other changes (career changes, migration, etc.)

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Simulate future sample paths of $P_{i,x,t}$ by simulating future $q_{x,t}$, $D_{i,x,t}$, $R_{i,x,t}$, $G_{i,t}$ and $E_{i,x,t}$

Working population: $P_{i,x,t}$

$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$
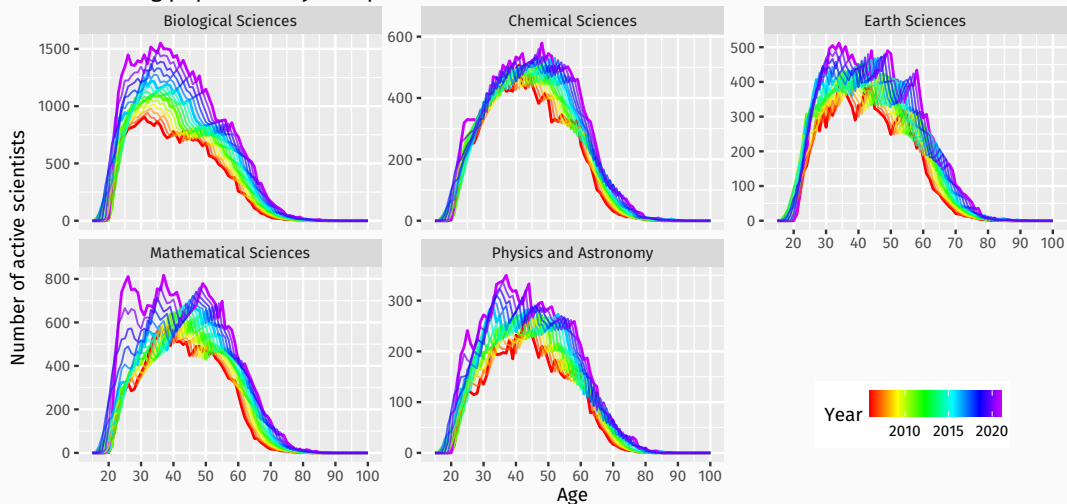

Working population by discipline
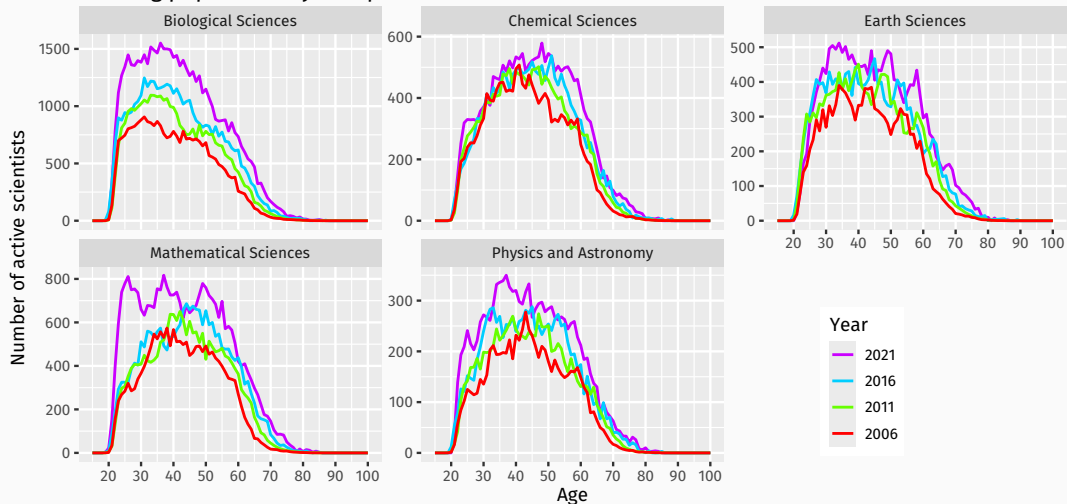
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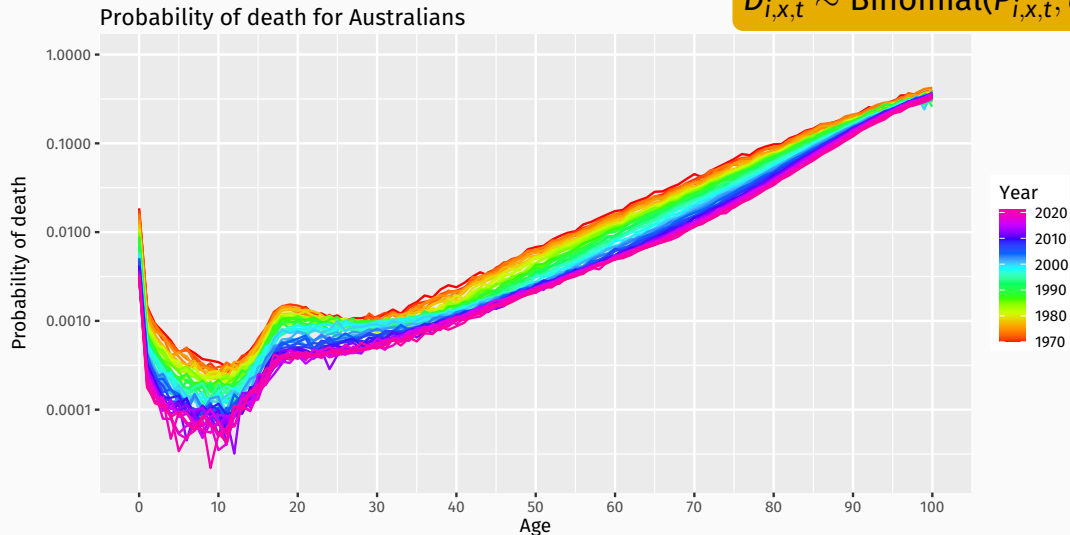
Working population by discipline

Death probability: $q_{x,t}$

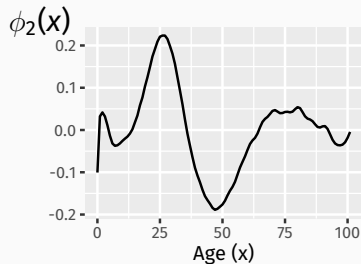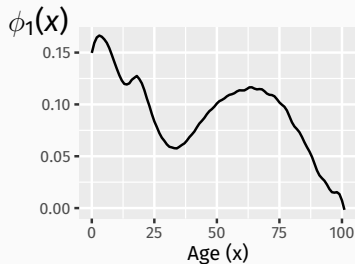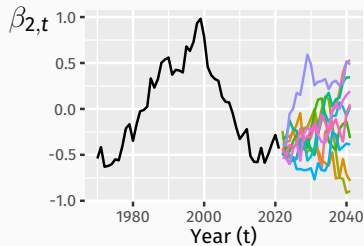$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

$$D_{i,x,t} \sim \text{Binomial}(P_{i,x,t}, q_{x,t})$$

Probability of death for Australians
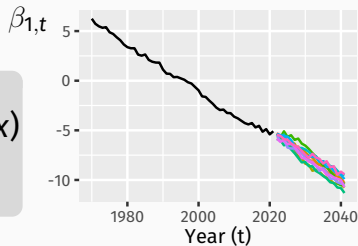
Death probability: $q_{x,t}$

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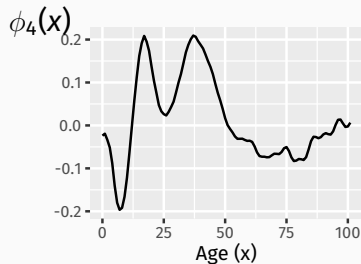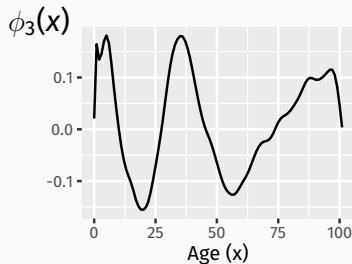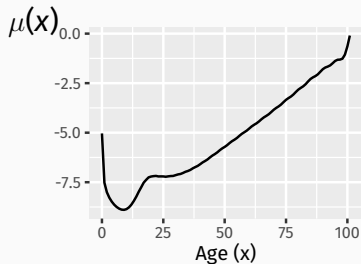$$q_{x,t} = \mu(x) + \sum_{k=1}^{6} \beta_{k,t}\phi_k(x) + \varepsilon_t(x)$$

$$\beta_{k,t} \sim \text{ARIMA}$$

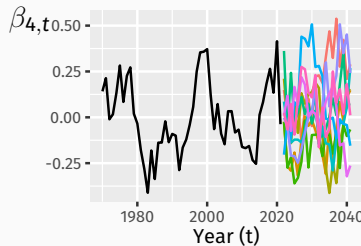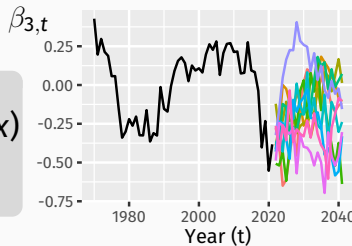# Death probability: $q_{x,t}$

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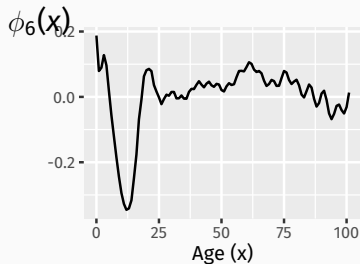$$q_{x,t} = \mu(x) + \sum_{k=1}^{6} \beta_{k,t}\phi_k(x) + \varepsilon_t(x)$$

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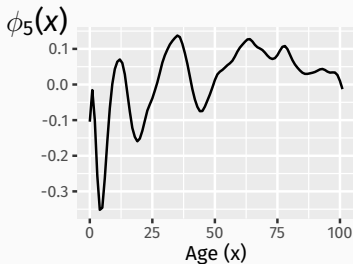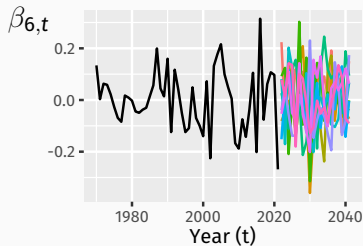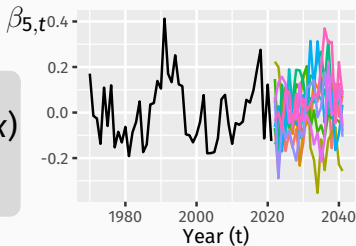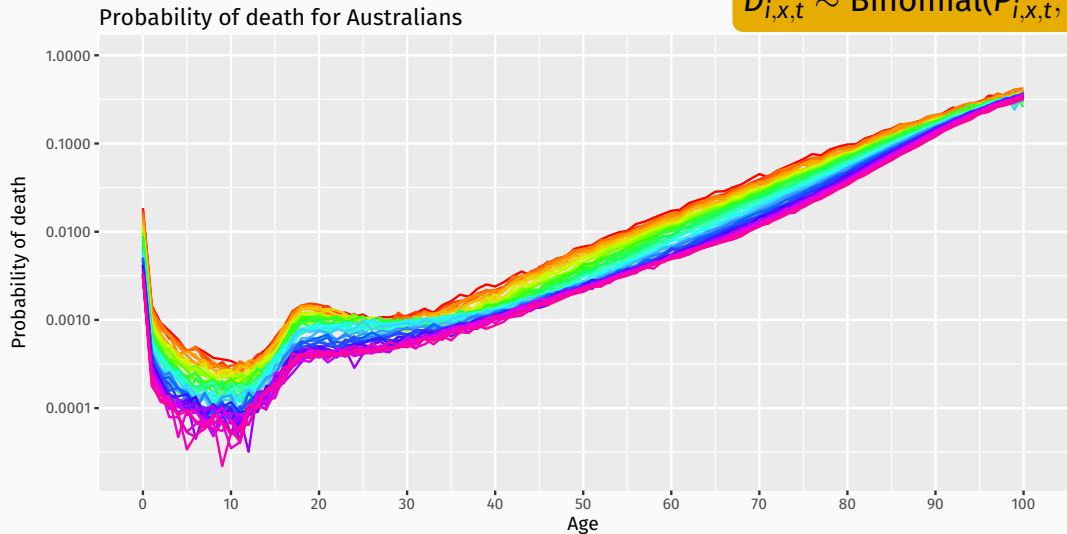
$$\beta_{k,t} \sim \text{ARIMA}$$

Death probability: $q_{x,t}$

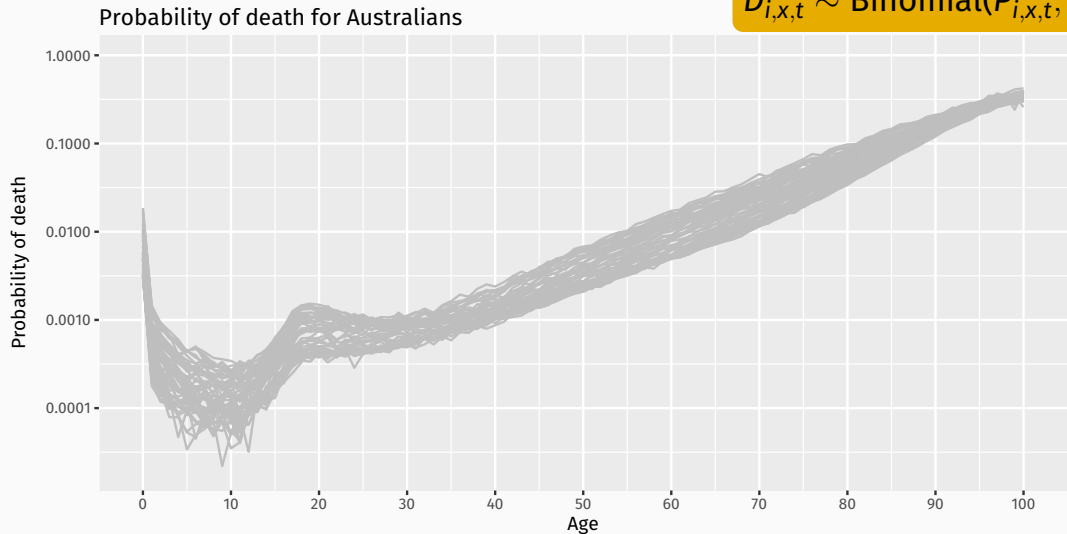$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

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Probability of death for Australians

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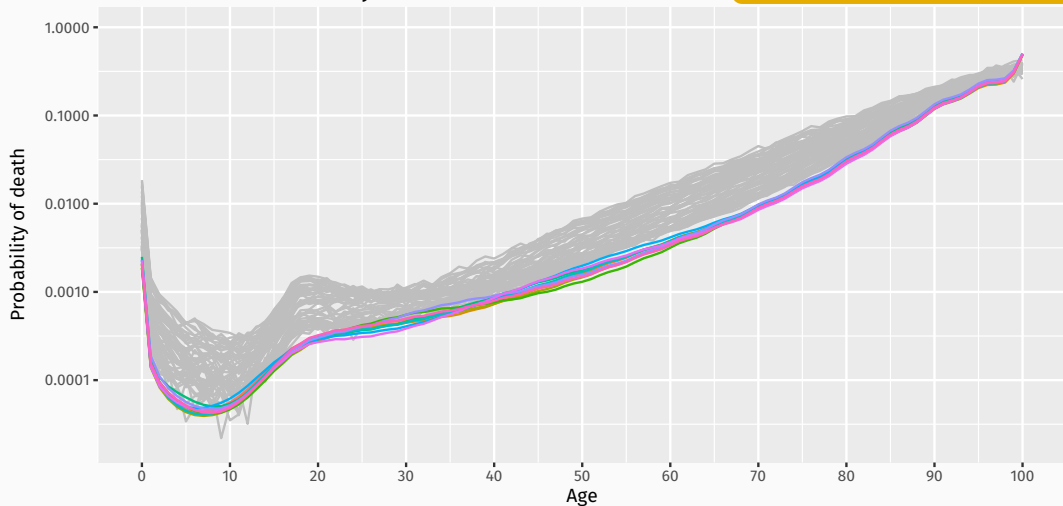
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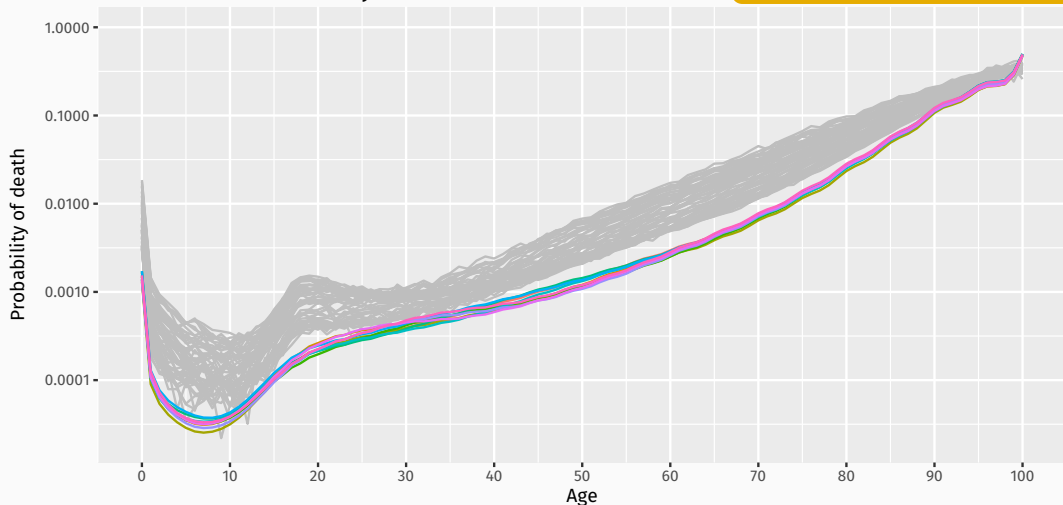

Simulated future mortality: 2030

Death probability: $q_{x,t}$

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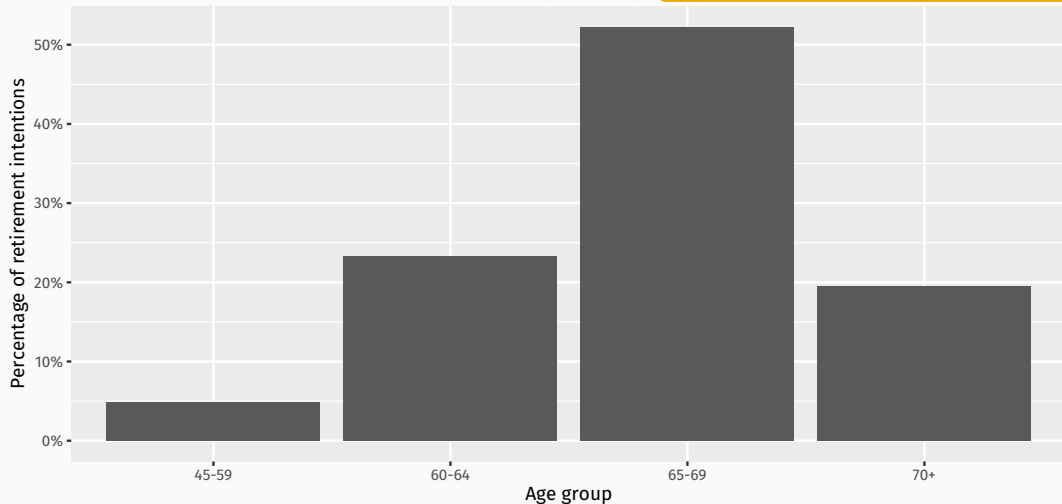

Simulated future mortality: 2040

Retirement rates: r_x

$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

$$R_{i,x,t} \sim \text{Binomial}(P_{i,x,t} - D_{i,x,t}, r_x)$$

Retirement intentions of Australian scientists (2022-23)

Retirement rates: r_x

$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

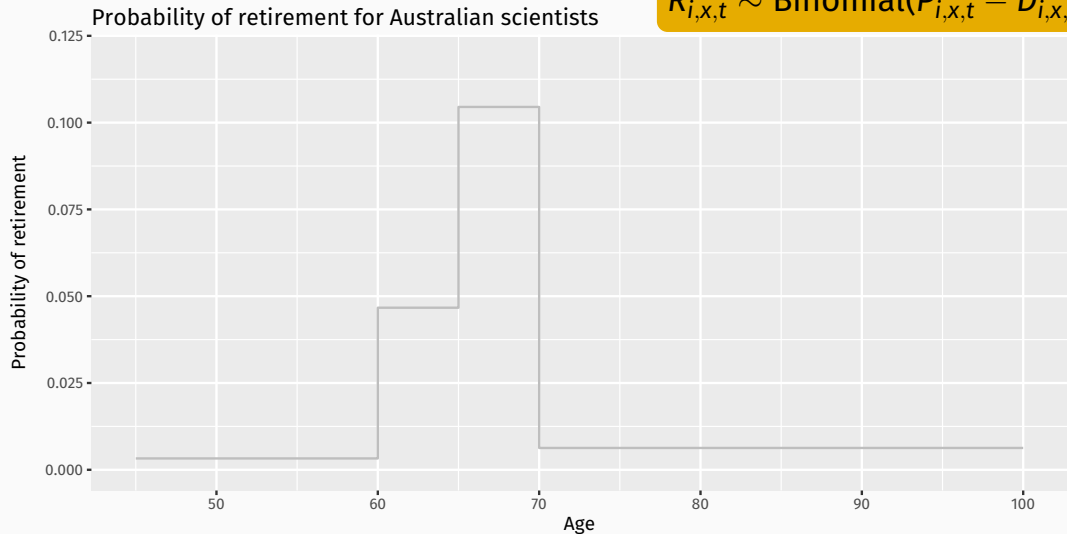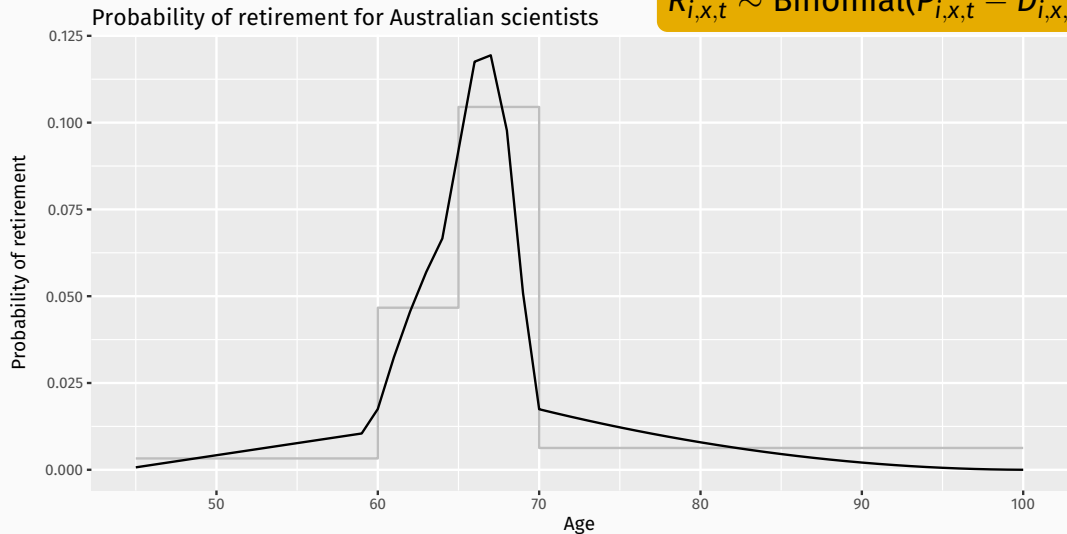$$R_{i,x,t} \sim \text{Binomial}(P_{i,x,t} - D_{i,x,t}, r_x)$$

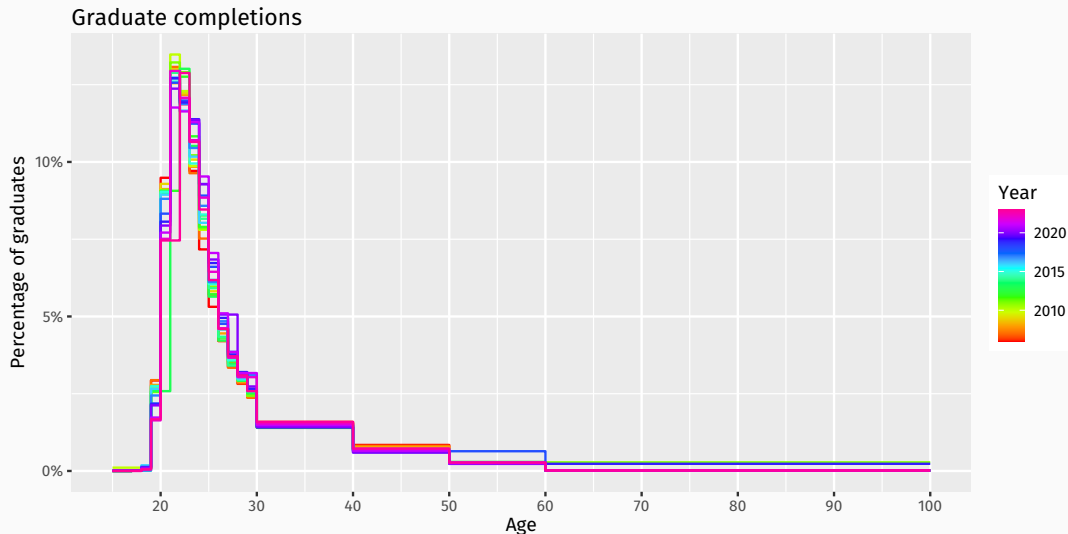Probability of retirement for Australian scientists

Retirement rates: r_x

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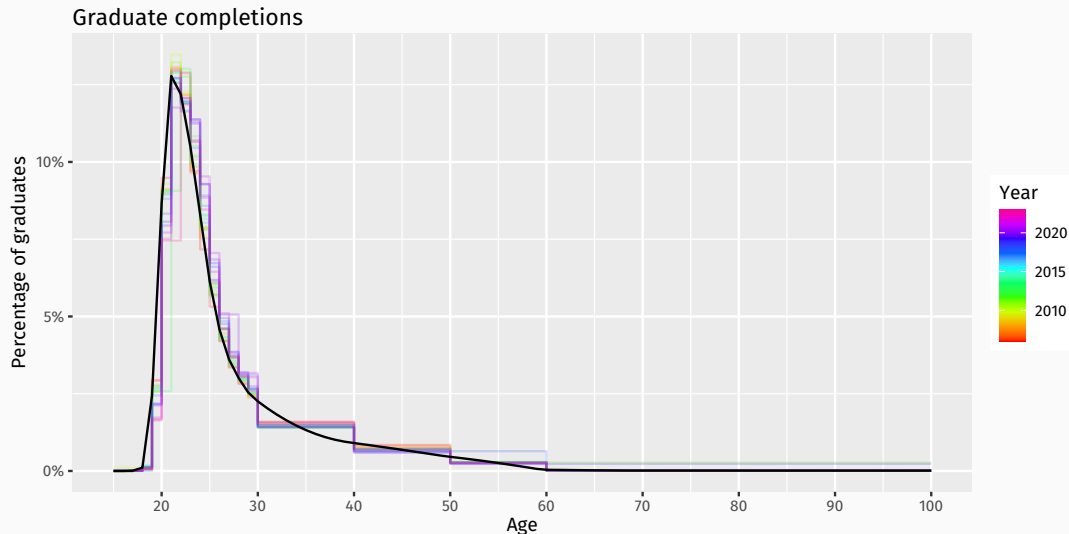$$R_{i,x,t} \sim \text{Binomial}(P_{i,x,t} - D_{i,x,t}, r_x)$$

Probability of retirement for Australian scientists

Graduate completions: g_x

$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

Graduate completions

Graduate completions: g_x

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Graduate completions

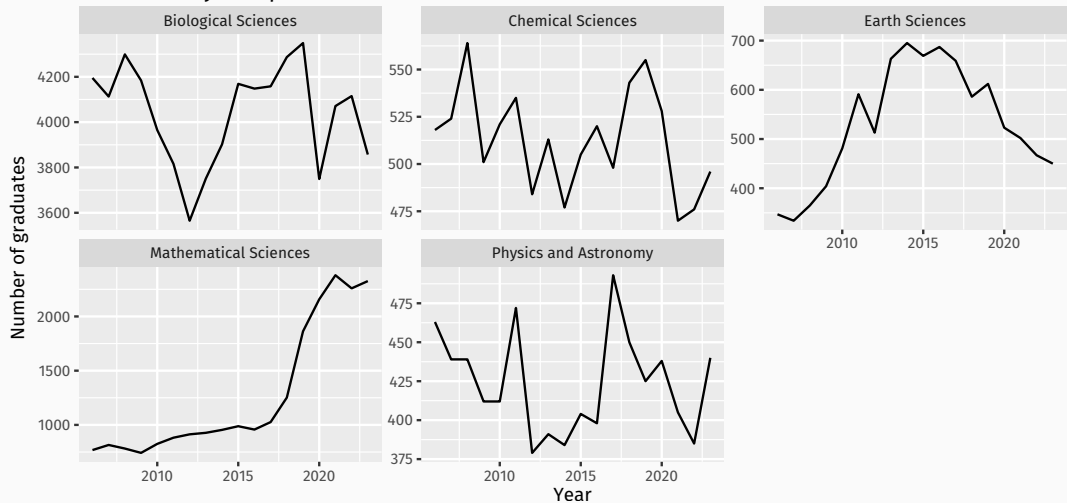# Graduate completions: $G_{i,t}$

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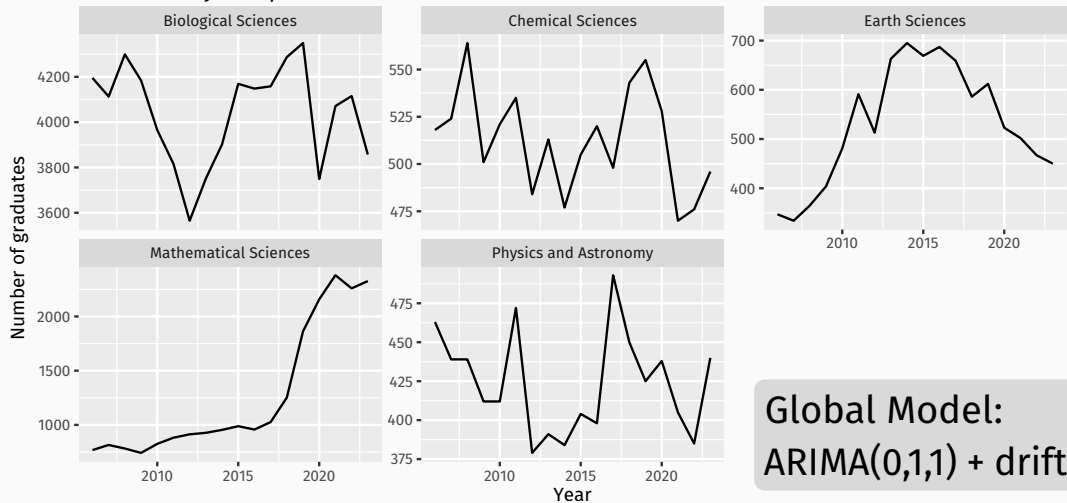

Graduates by discipline

Graduate completions: $G_{i,t}$

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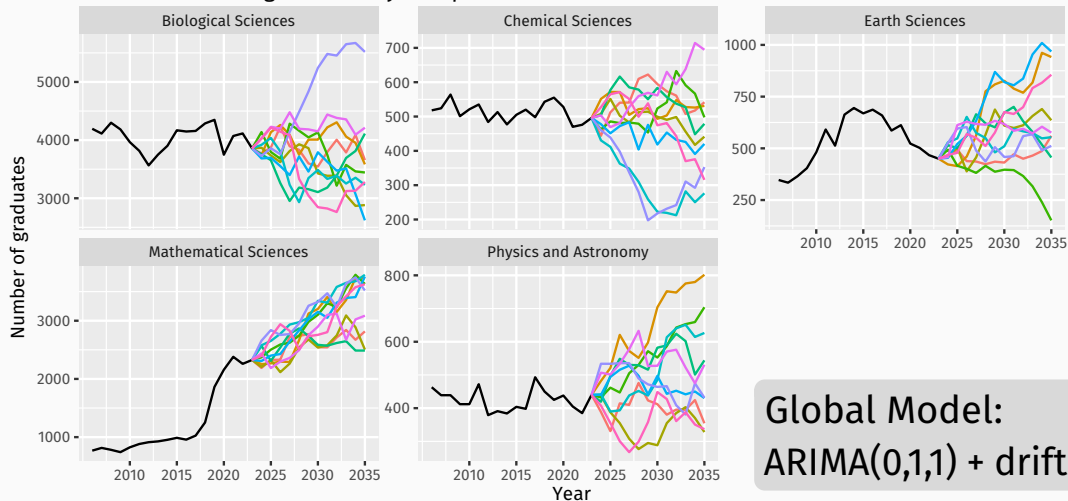

Graduates by discipline

Global Model:
ARIMA(0,1,1) + drift

Graduate completions: $G_{i,t}$

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Forecasts of total graduates by discipline

Global Model:
ARIMA(0,1,1) + drift

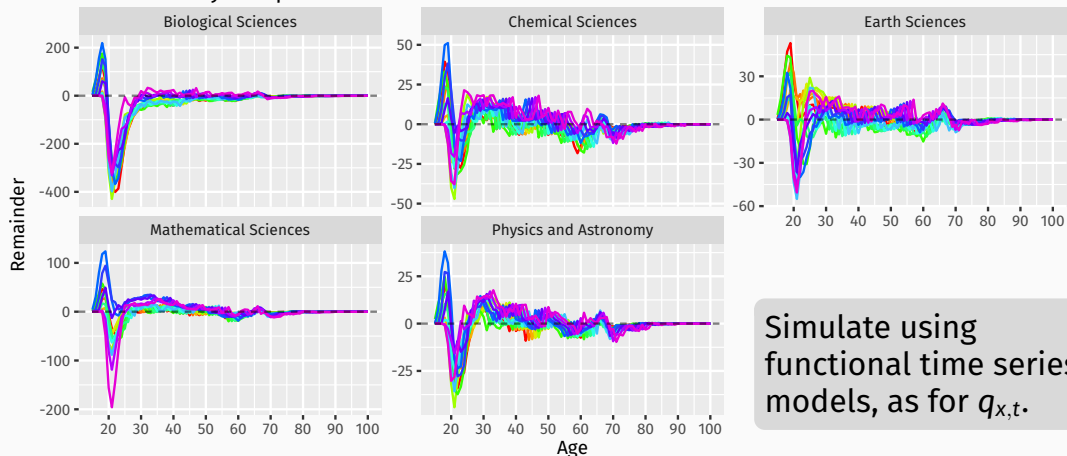$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

$$E_{i,x,t} = P_{i,x+1,t+1} - P_{i,x,t} + D_{i,x,t} + R_{i,x,t} - g_x G_{i,t}$$

Remainder: $E_{x,t}$

$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

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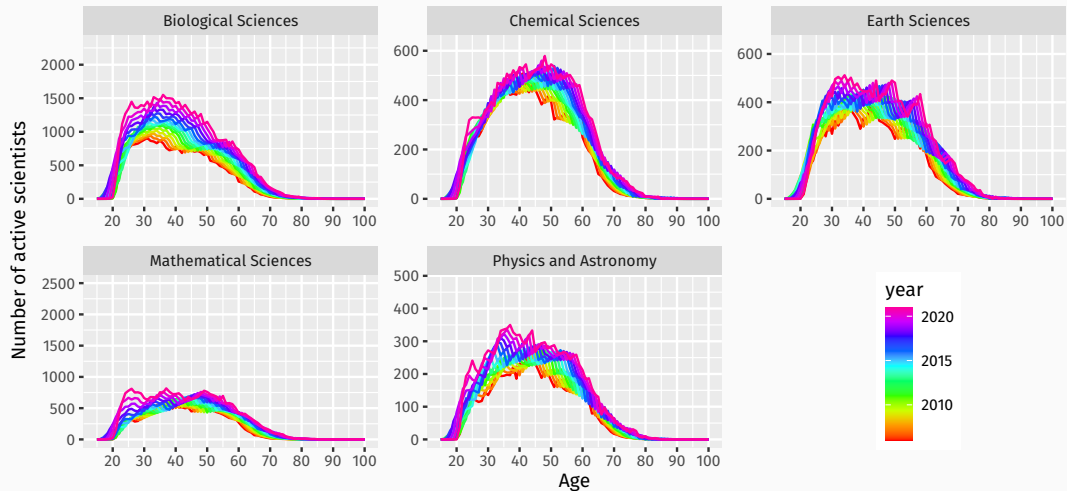
Remainder by discipline

Simulate using functional time series models, as for $q_{x,t}$.

Population: $P_{i,x,t}$

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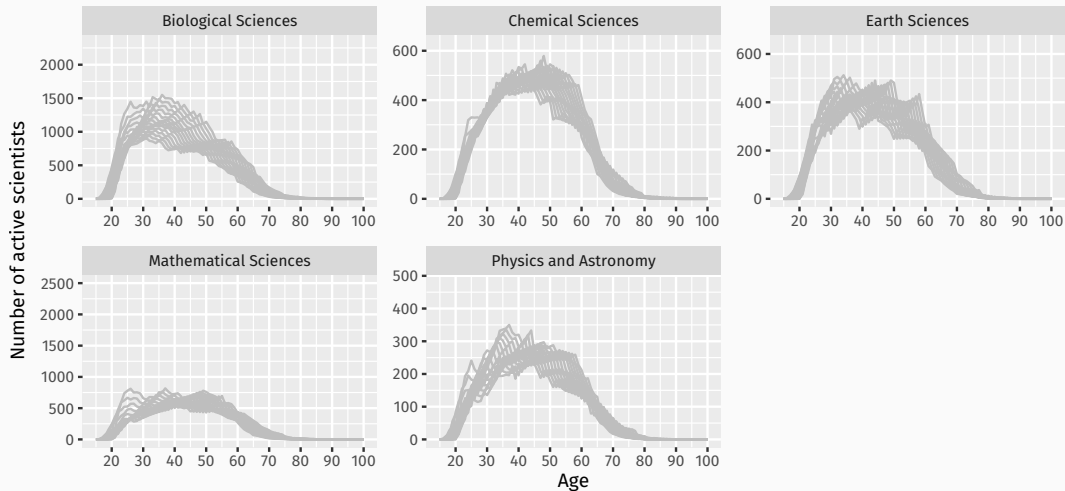
Working population by discipline

Population: $P_{i,x,t}$

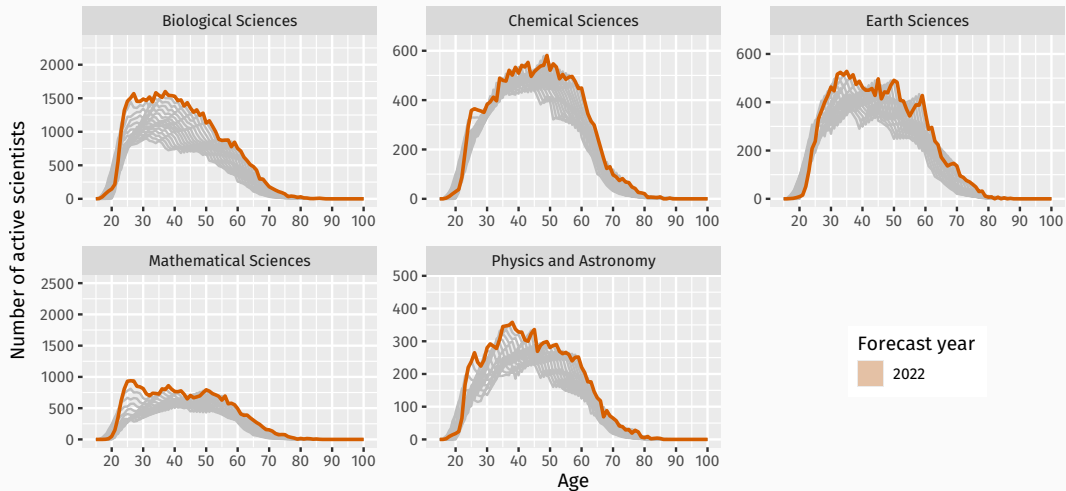$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

Working population by discipline

Forecasts by discipline

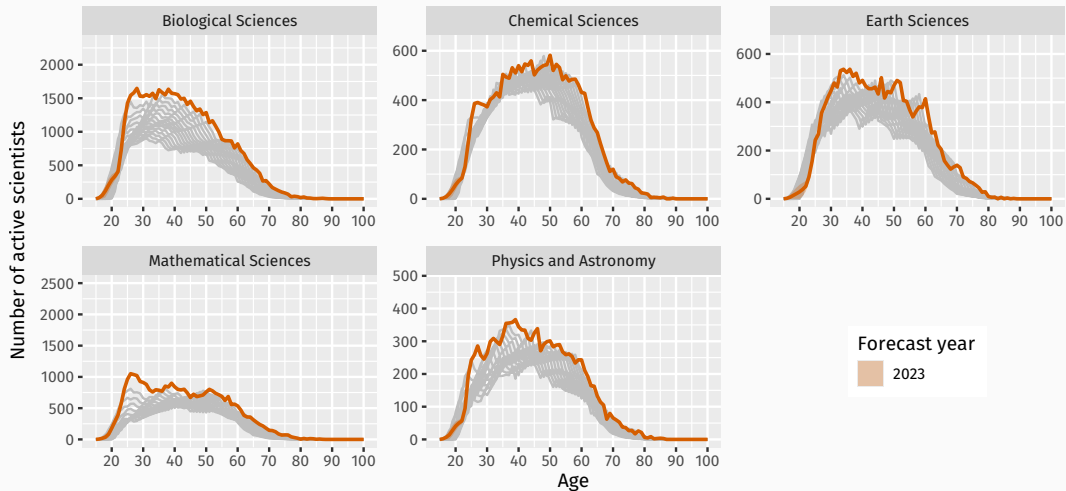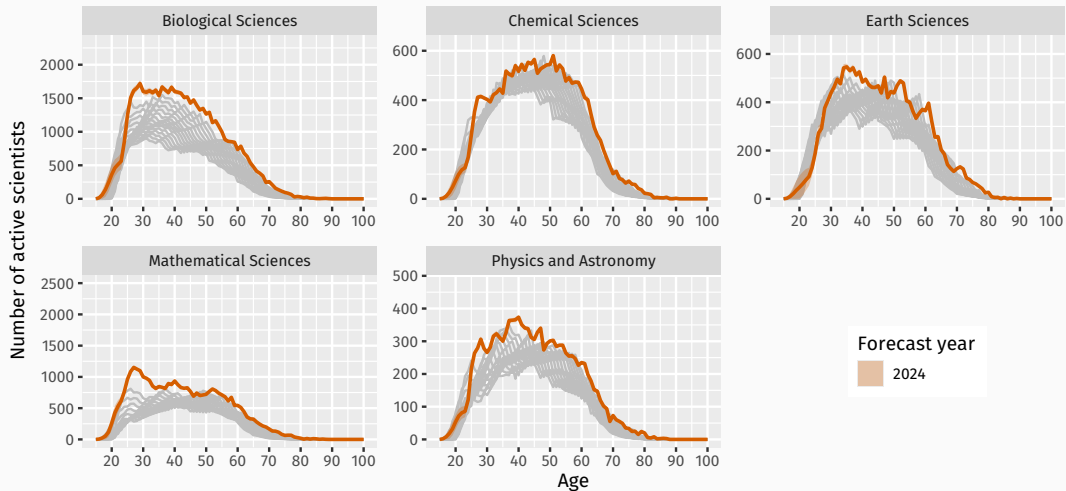$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

Forecast of working population by discipline

Forecasts by discipline

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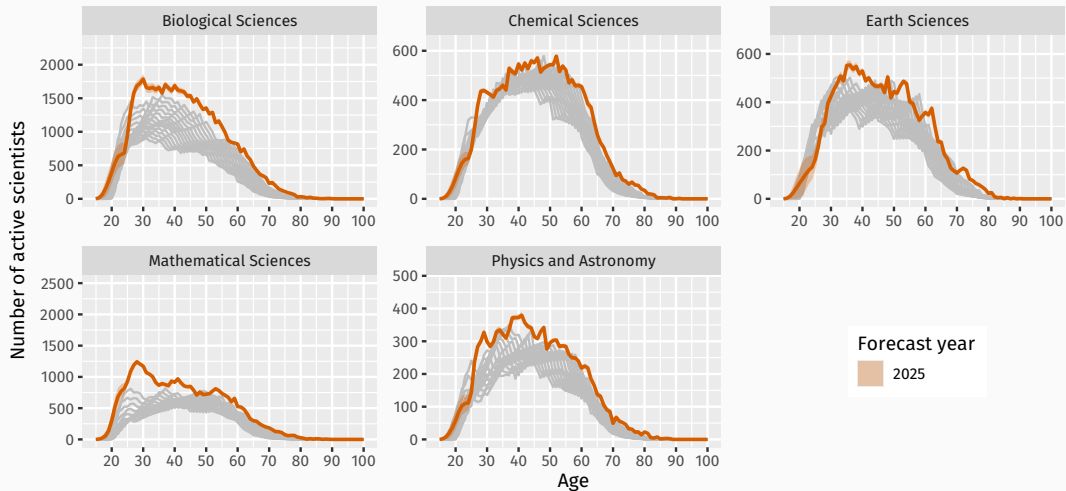
Forecast of working population by discipline

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Forecast of working population by discipline

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Forecasts by discipline

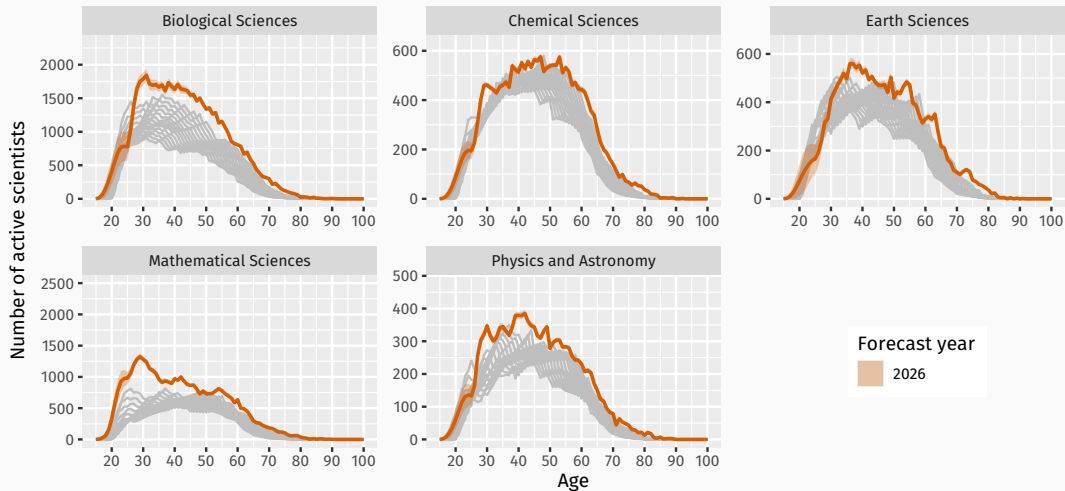$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

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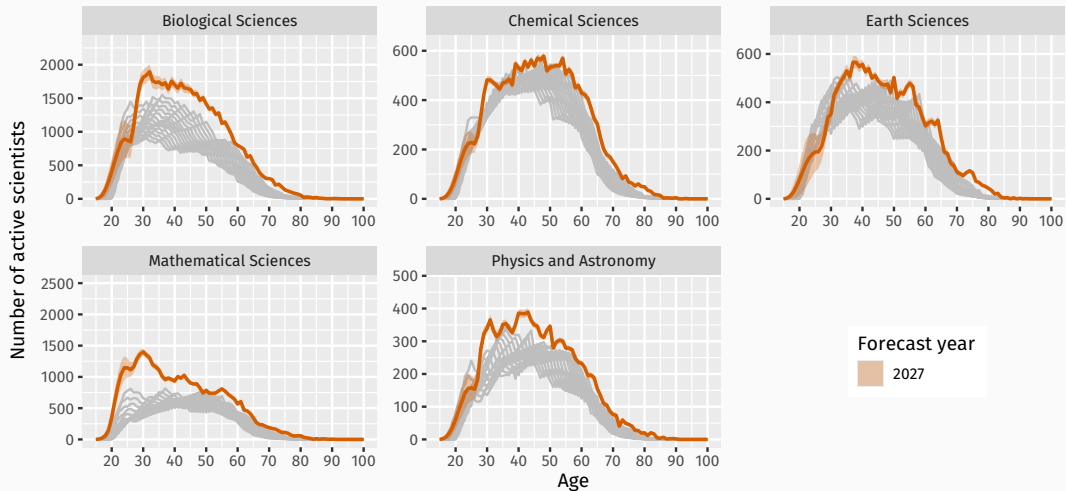Forecast of working population by discipline

Forecasts by discipline

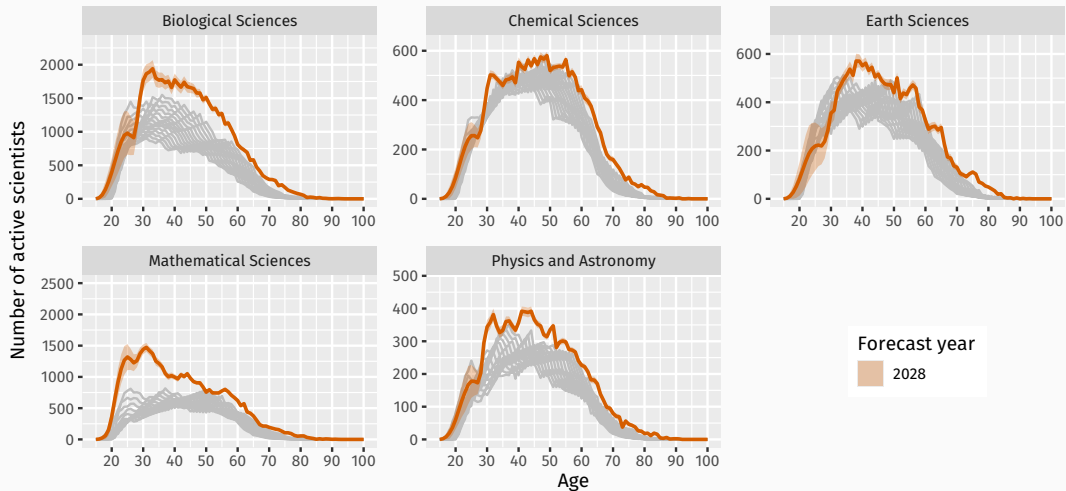$$P_{i,x+1,t+1} = P_{i,x,t} - D_{i,x,t} - R_{i,x,t} + g_x G_{i,t} + E_{i,x,t}$$

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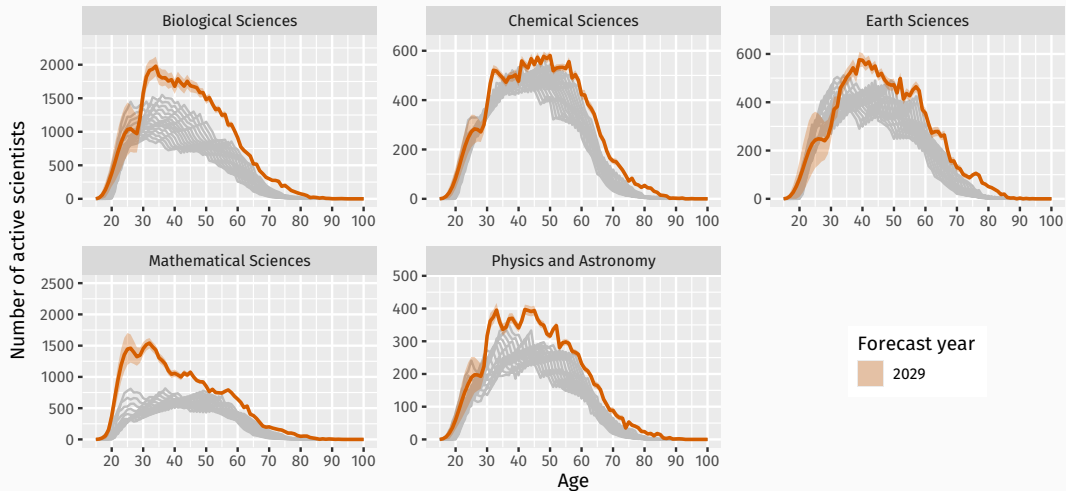Forecast of working population by discipline

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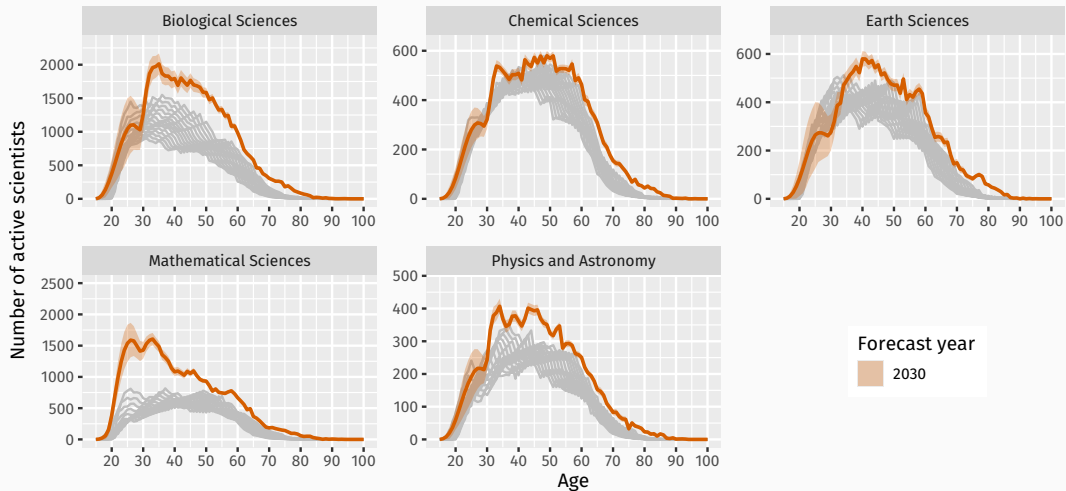Forecast of working population by discipline

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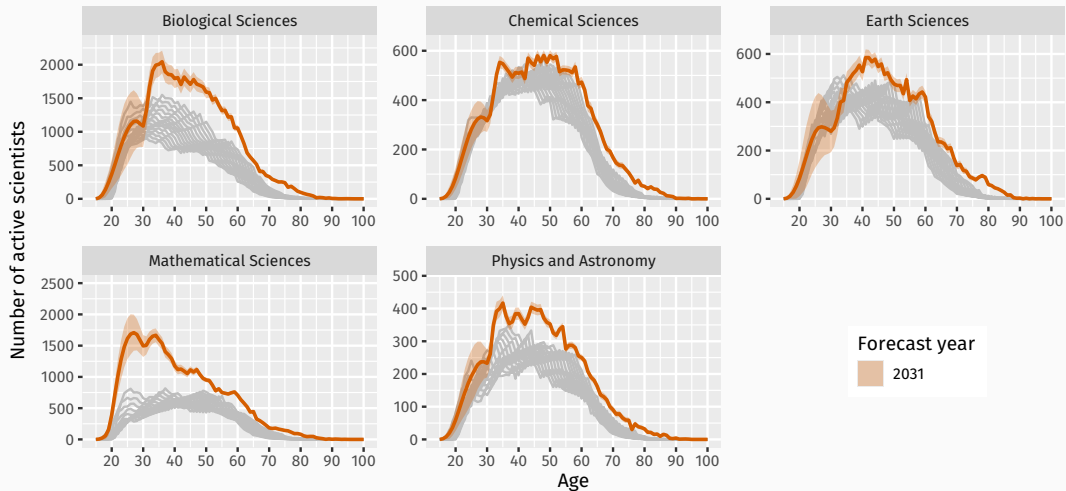Forecast of working population by discipline

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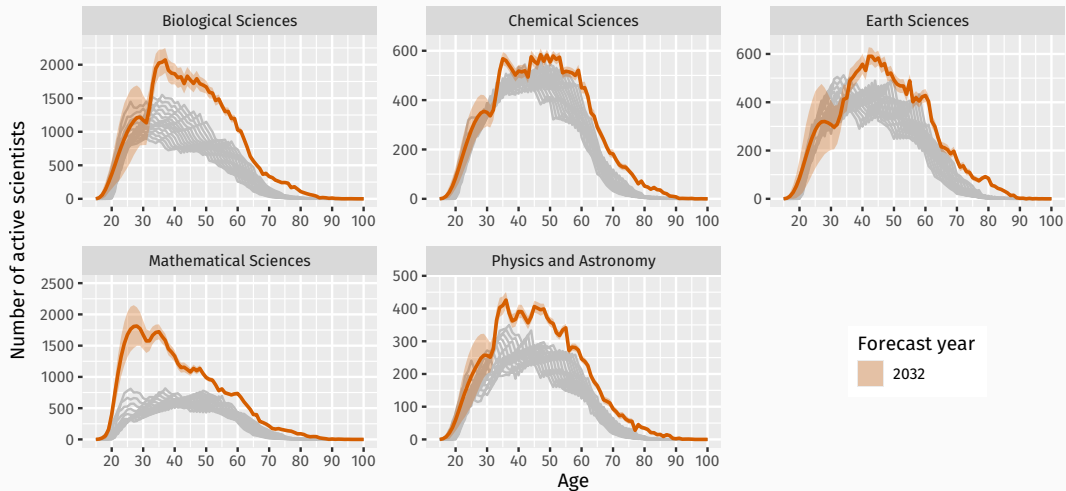Forecast of working population by discipline

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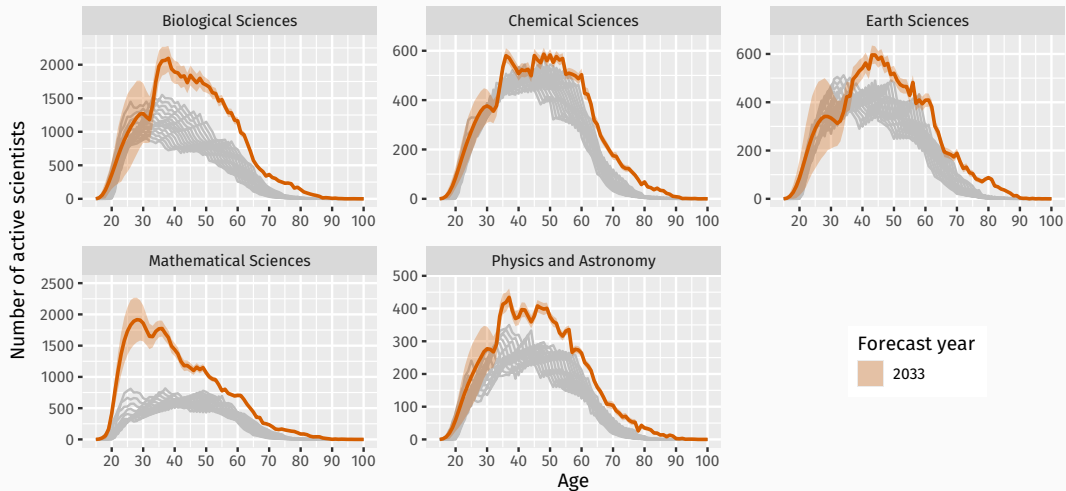Forecast of working population by discipline

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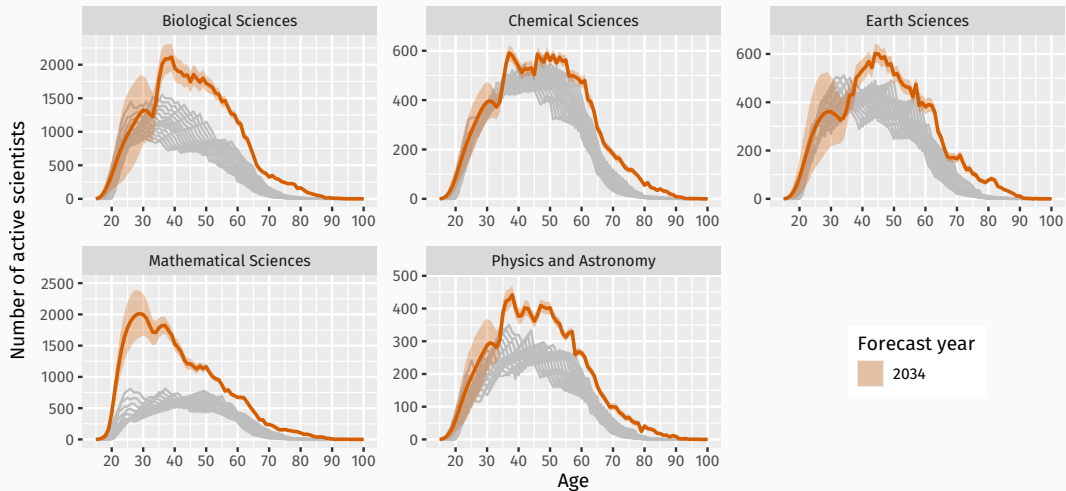Forecast of working population by discipline

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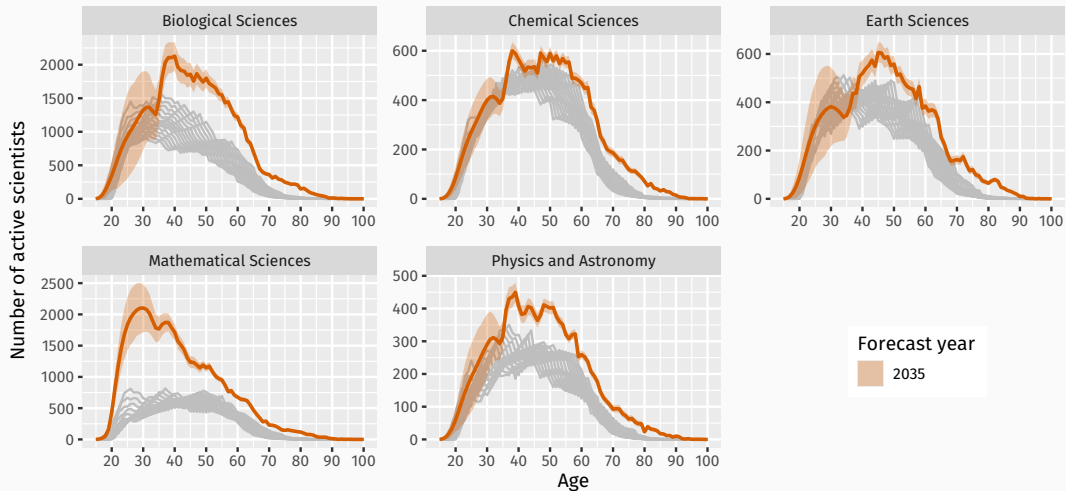Forecast of working population by discipline

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Forecast of working population by discipline

robjhyndman.com/asc2025