

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

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

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

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

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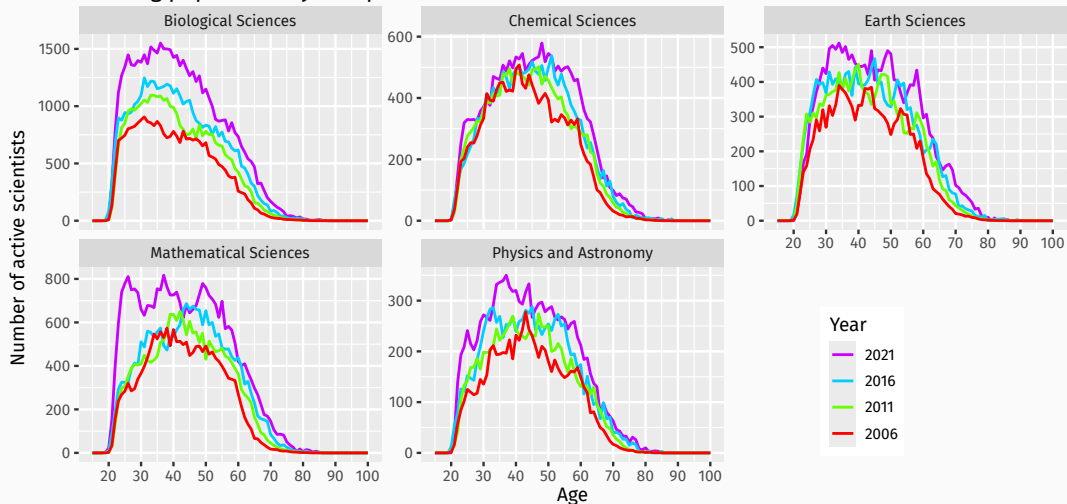
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Simulate future sample paths of  $P_{i,x,t}$  by simulating future  $q_{x,t}$ ,  $D_{i,x,t}$ ,  $R_{i,x,t}$ ,  $G_{i,t}$  and  $E_{i,x,t}$

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

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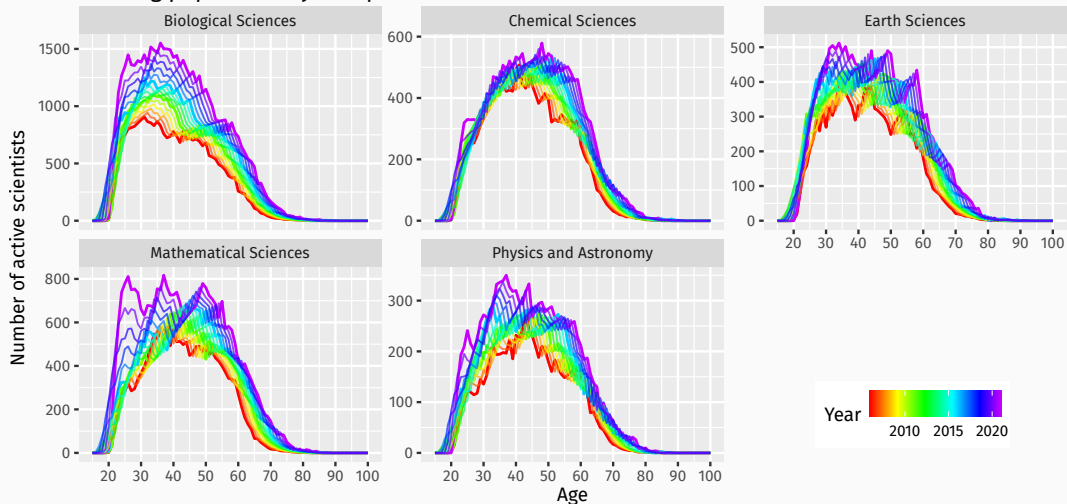
Working population by discipline



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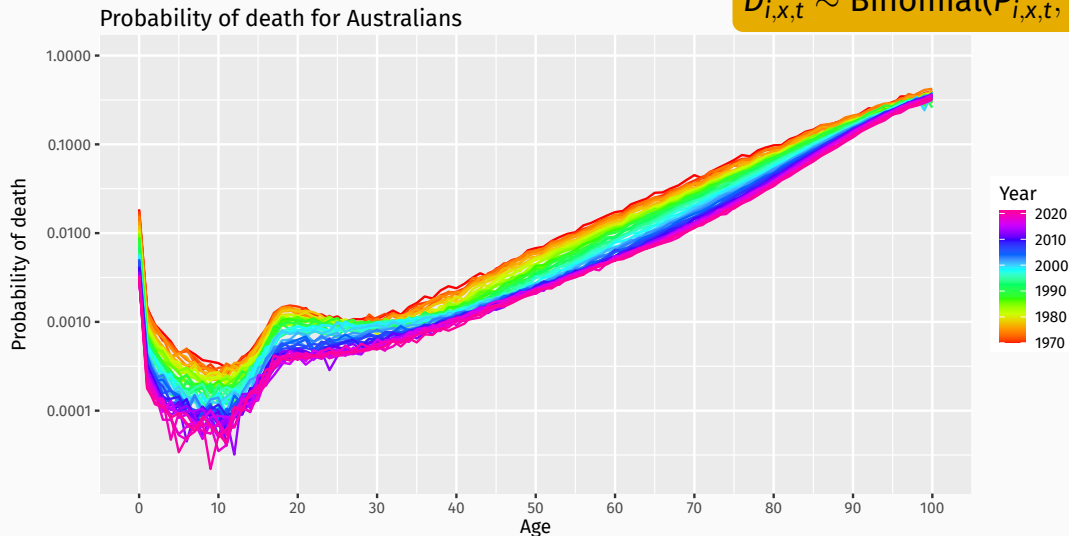
Working population by discipline



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

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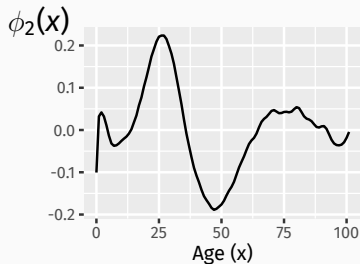
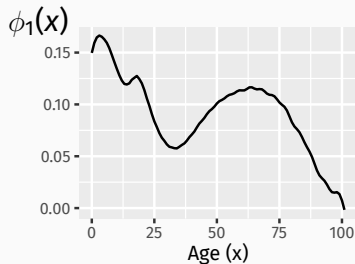
$$D_{i,x,t} \sim \text{Binomial}(P_{i,x,t}, q_{x,t})$$



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

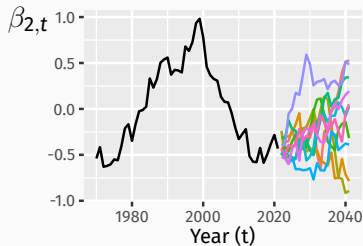
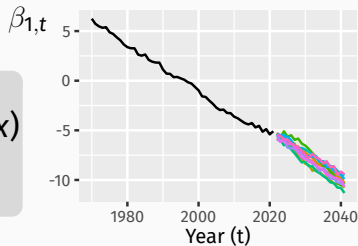
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$$q_{x,t} = \mu(x) + \sum_{k=1}^6 \beta_{k,t} \phi_k(x) + \varepsilon_t(x)$$

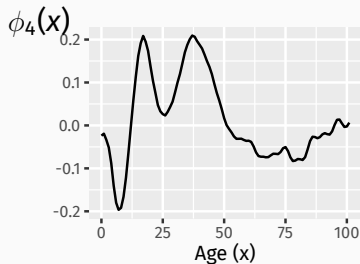
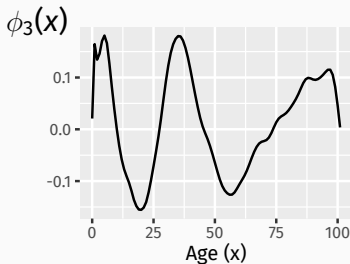
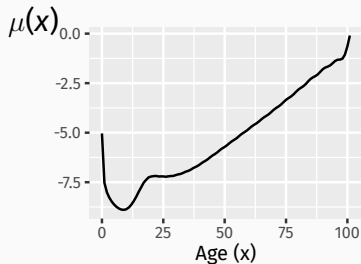
$\beta_{k,t} \sim \text{ARIMA}$



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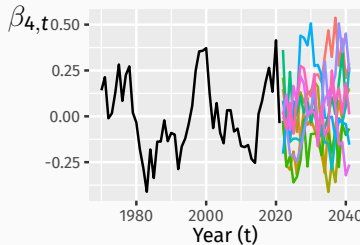
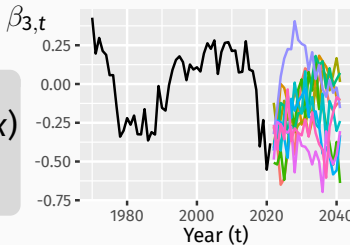
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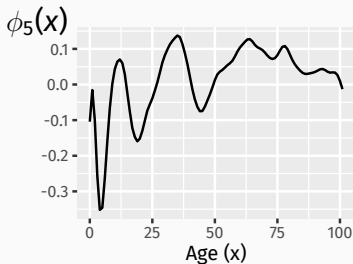




# Death probability: $q_{x,t}$

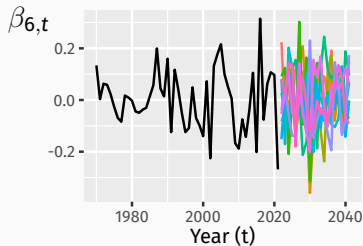
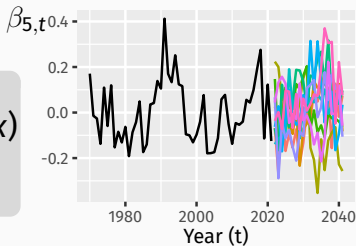
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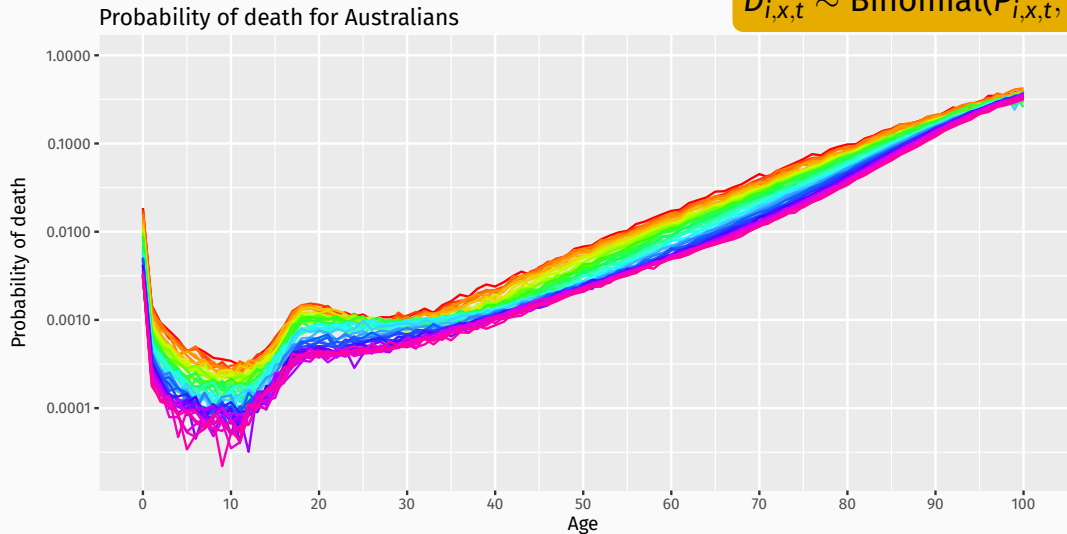
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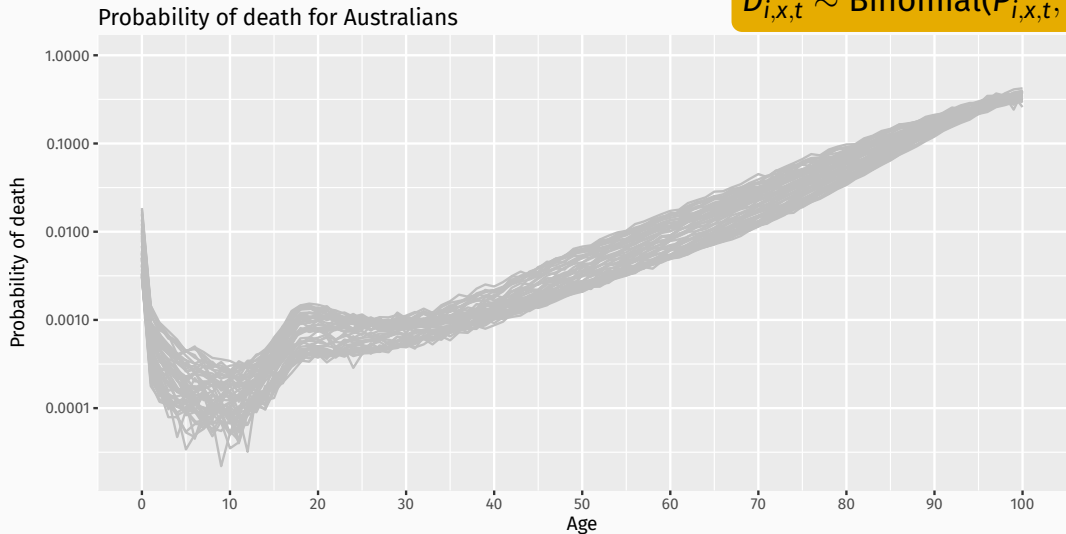
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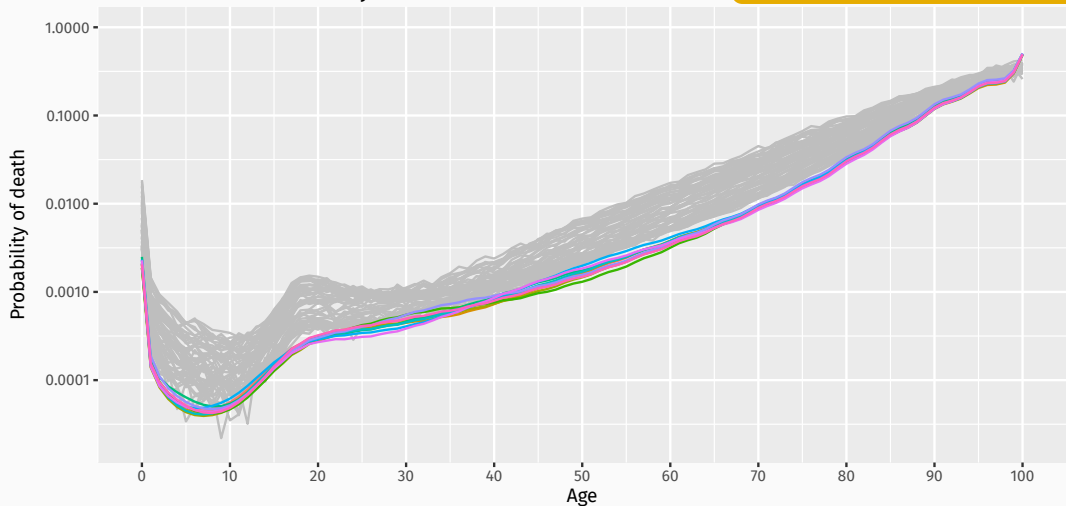


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Simulated future mortality: 2030

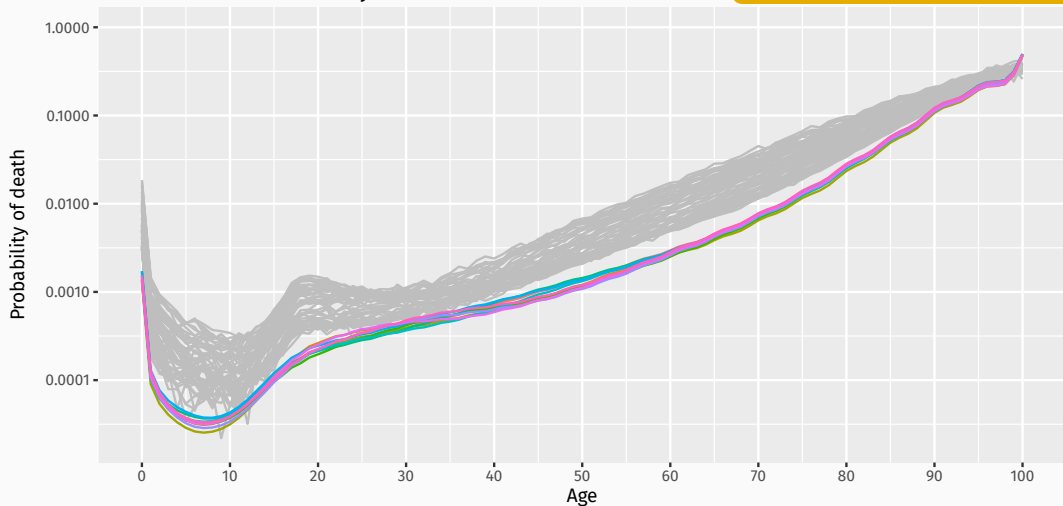


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Simulated future mortality: 2040

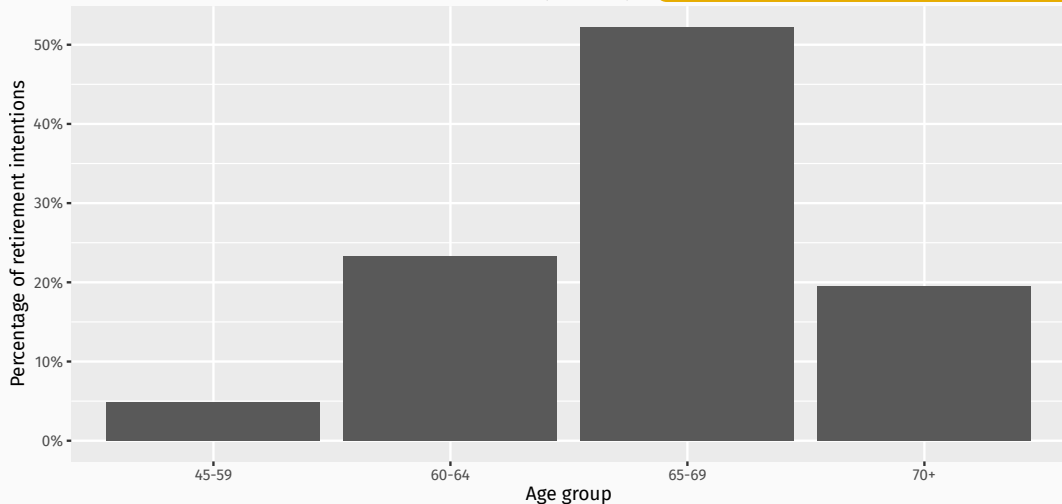


# Retirement rates: $r_x$

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

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

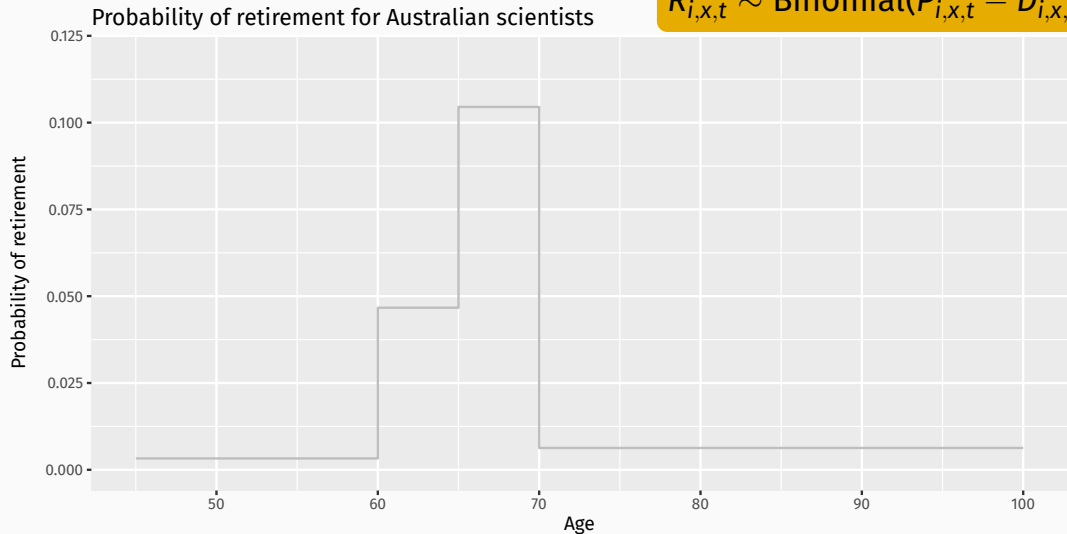
Retirement intentions of Australian scientists (2022-23)



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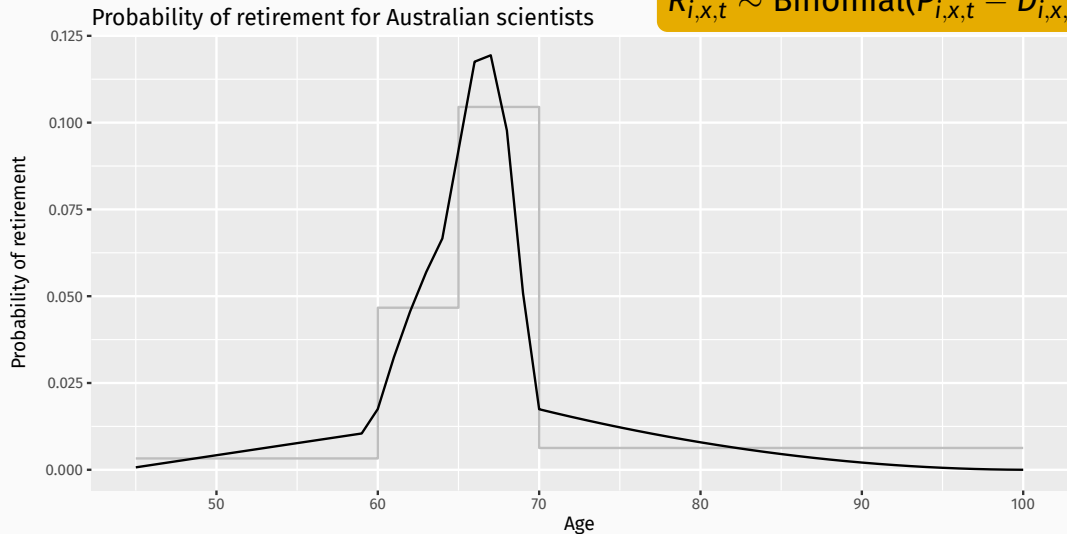
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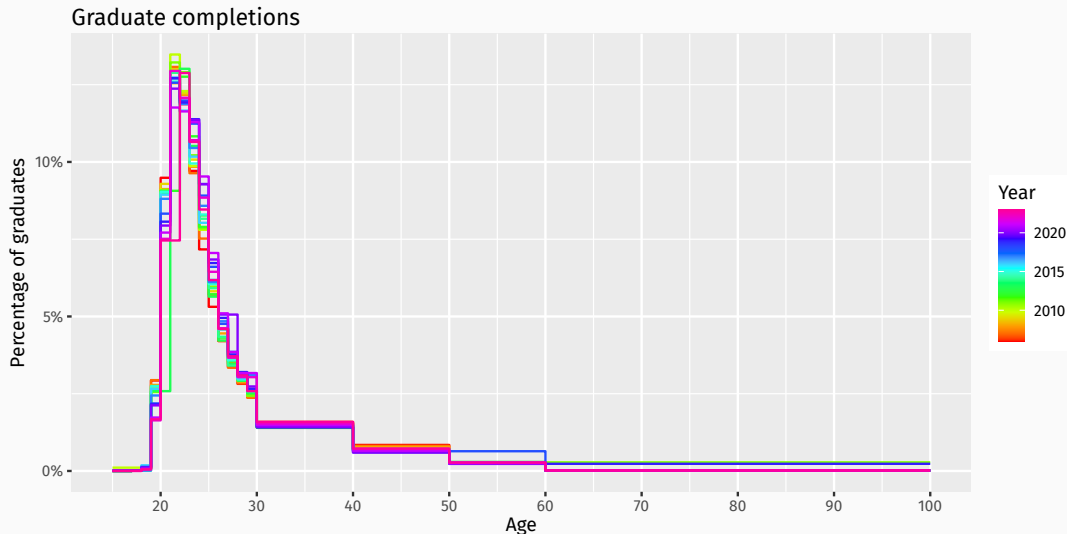
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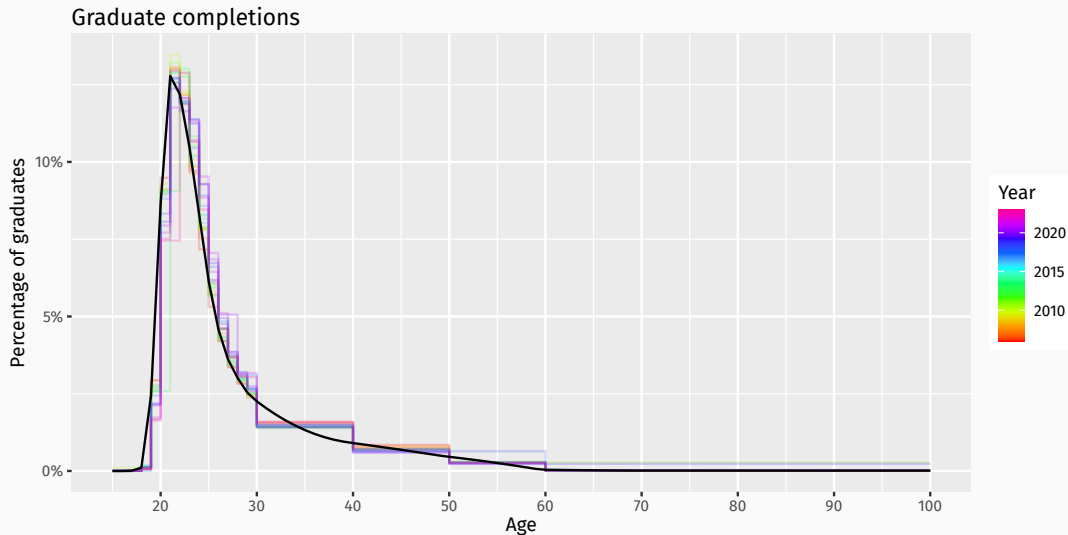
# Graduate completions: $g_x$

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# Graduate completions: $g_x$

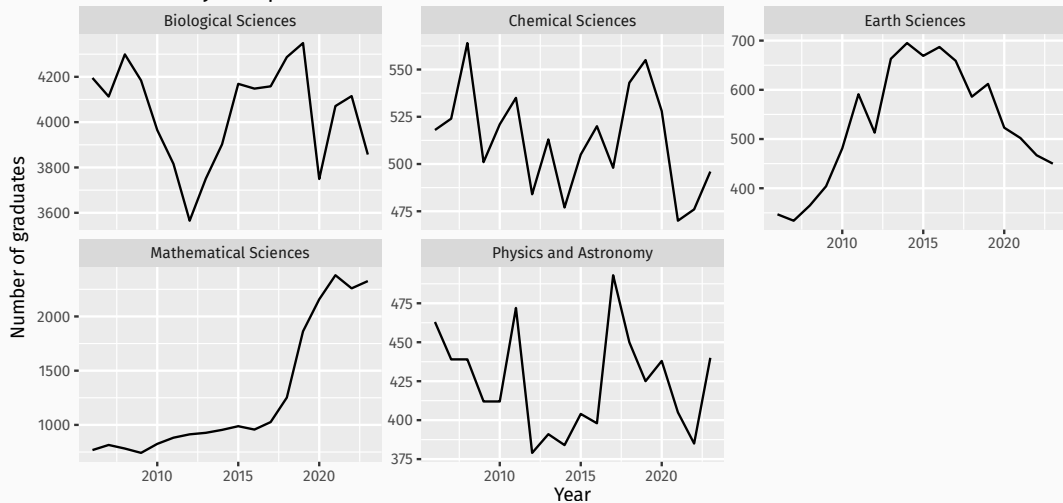
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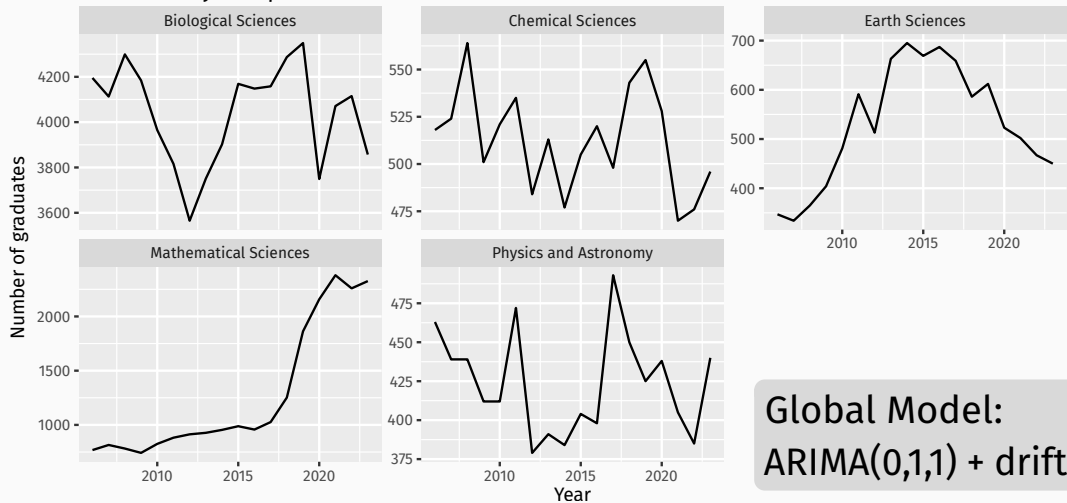
Graduates by discipline



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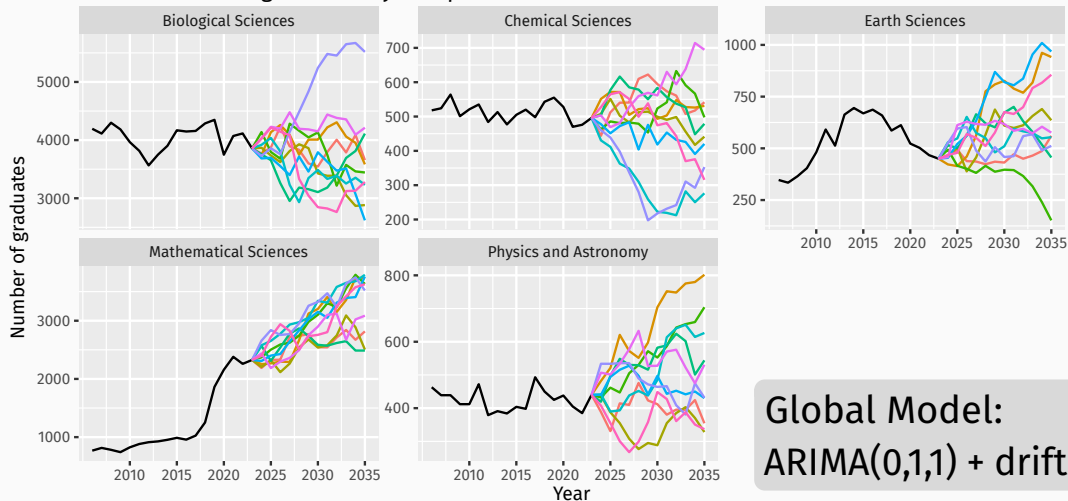


Global Model:  
ARIMA(0,1,1) + drift

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Forecasts of total graduates by discipline



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

**Remainder:**  $E_{x,t}$

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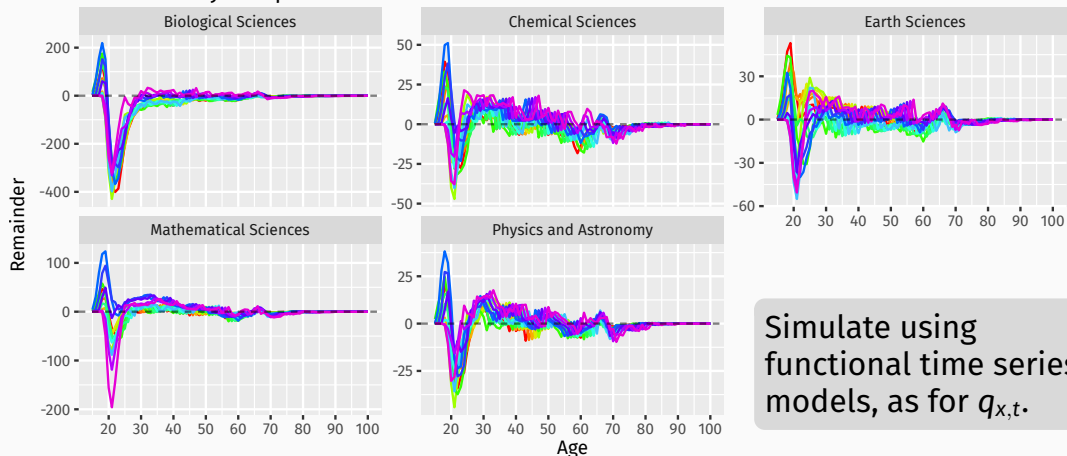
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Remainder by discipline



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

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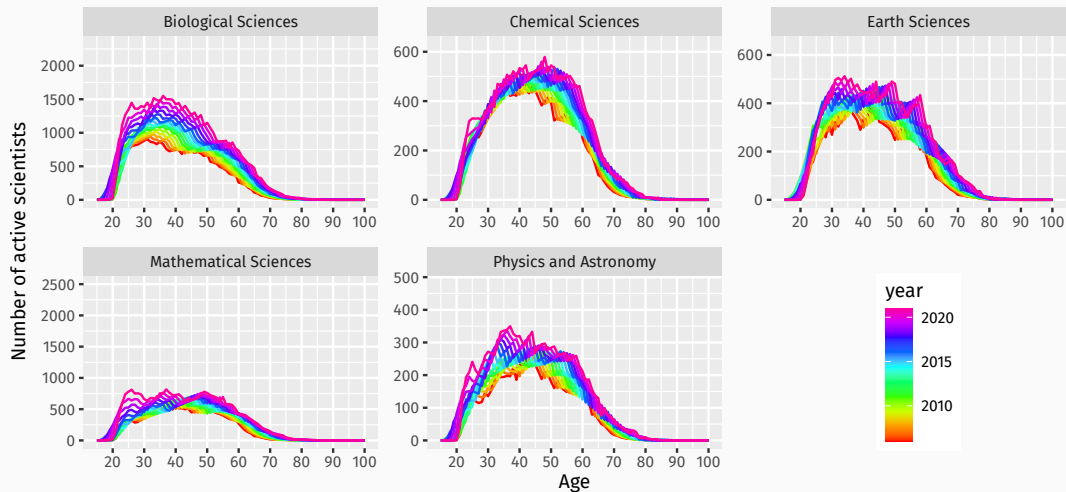
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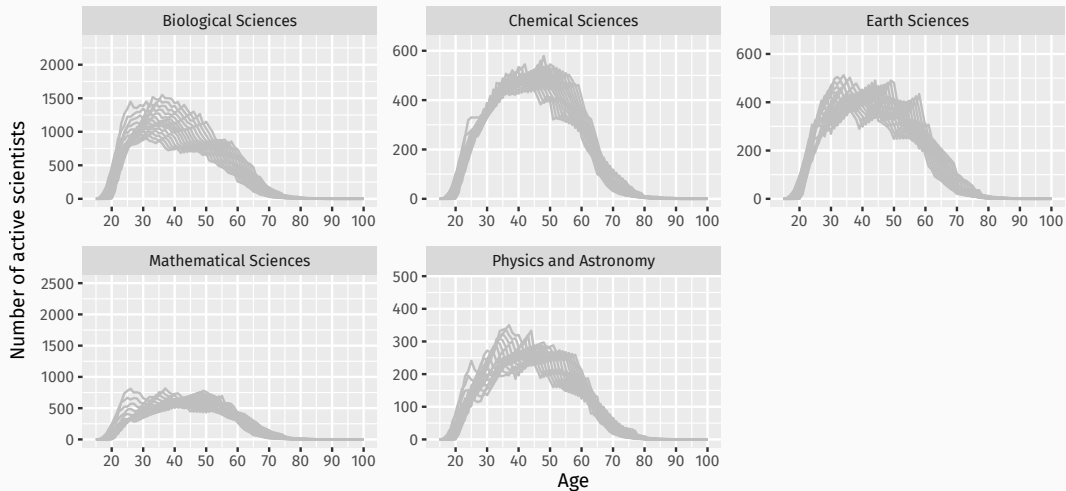
## Working population by discipline



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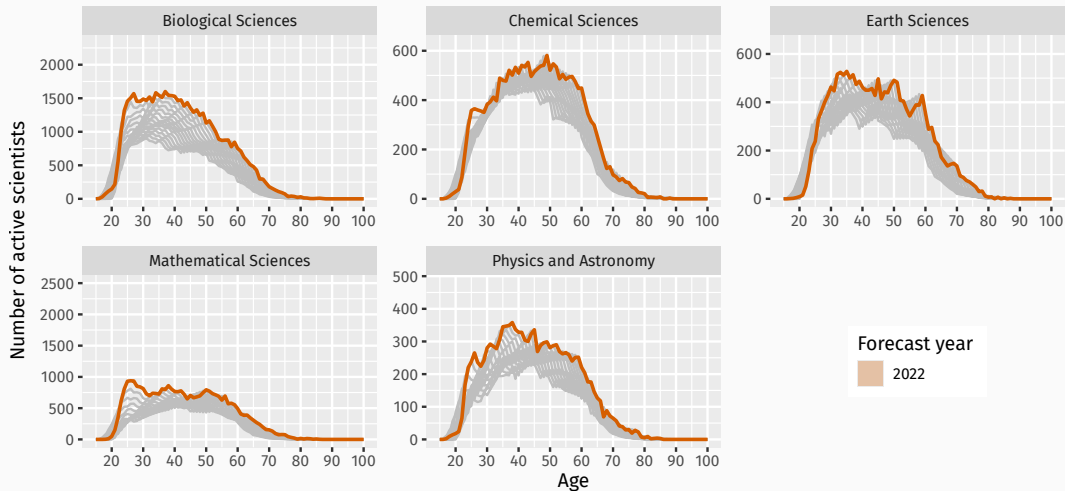
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# Forecasts by discipline

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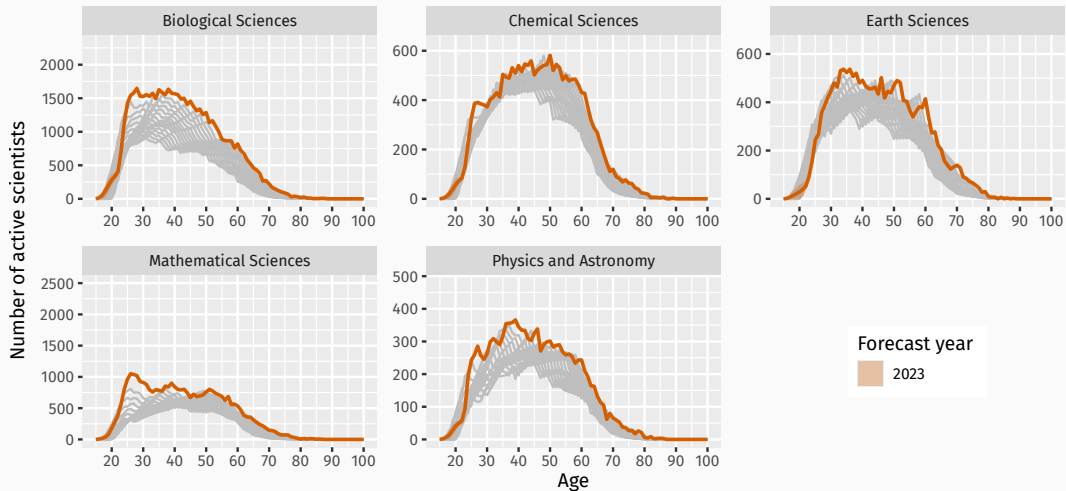
## Forecast of working population by discipline



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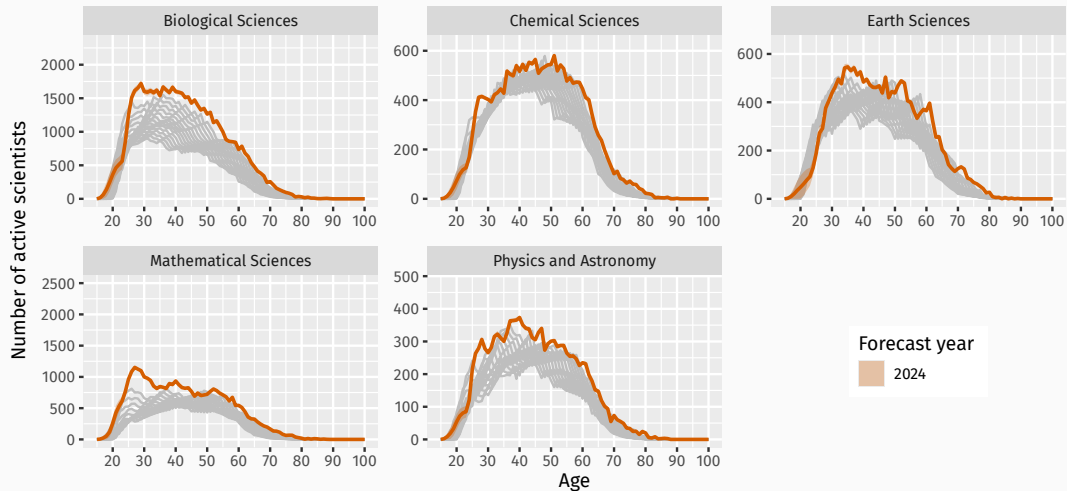
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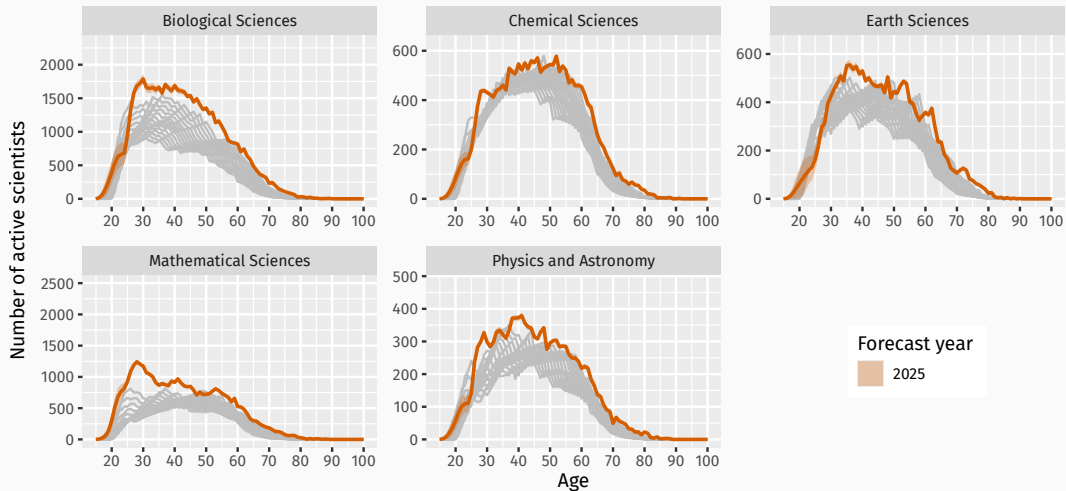
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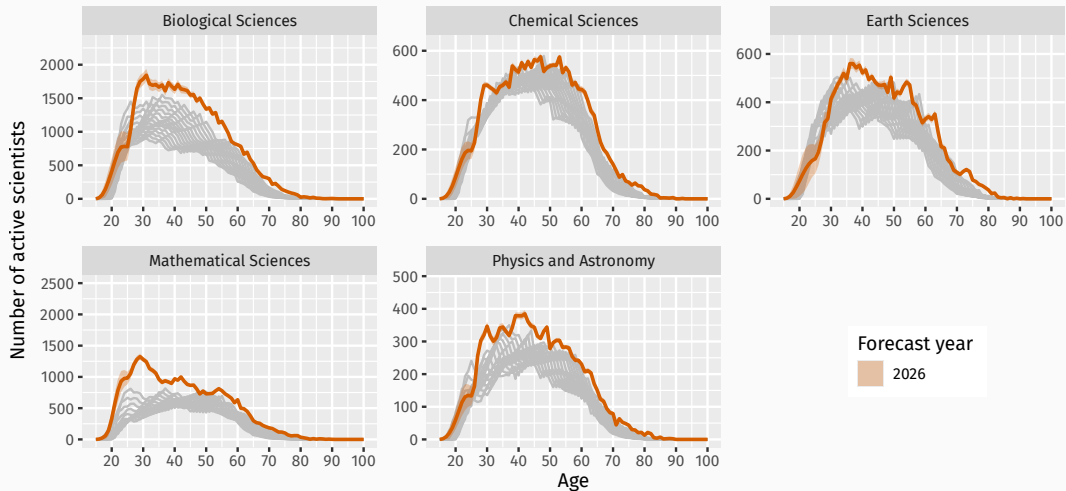
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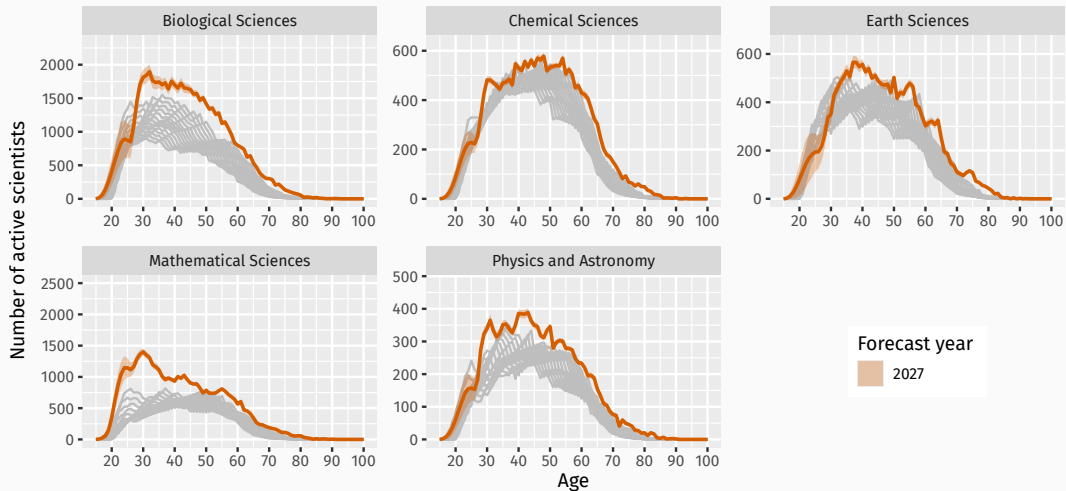
Forecast of working population by discipline



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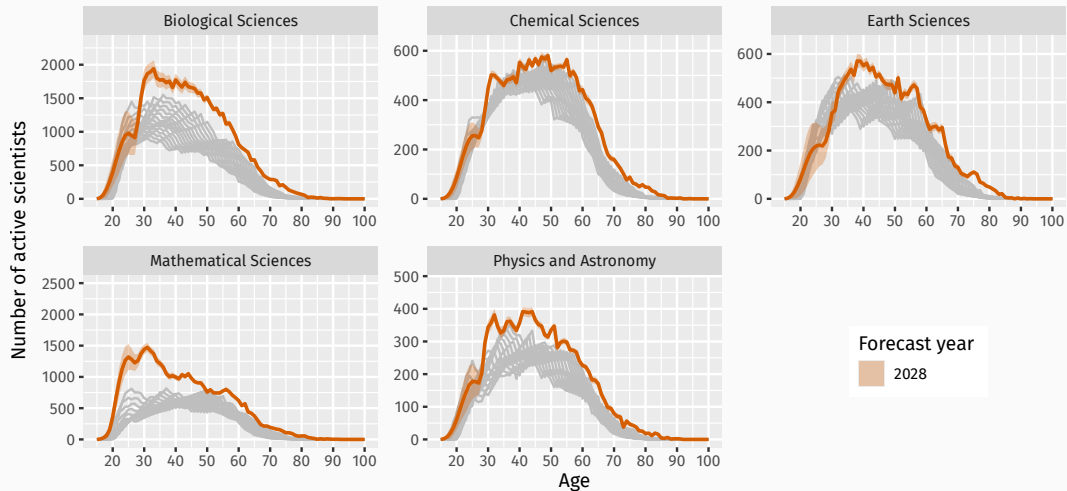




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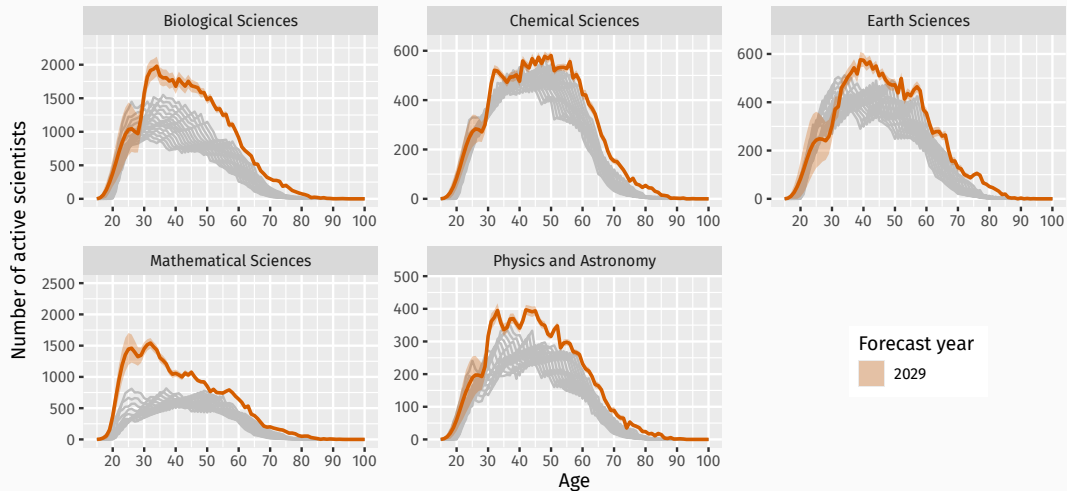
Forecast of working population by discipline



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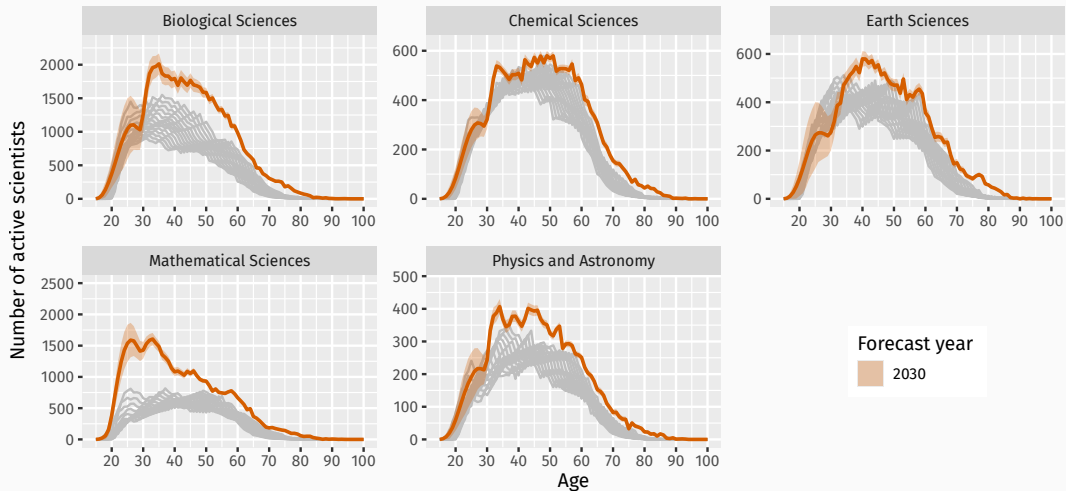
Forecast of working population by discipline



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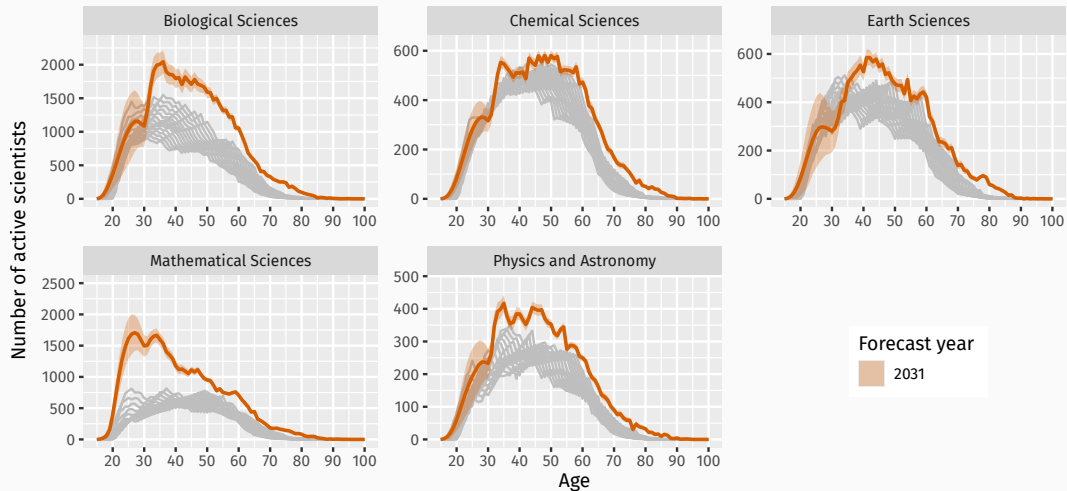
Forecast of working population by discipline



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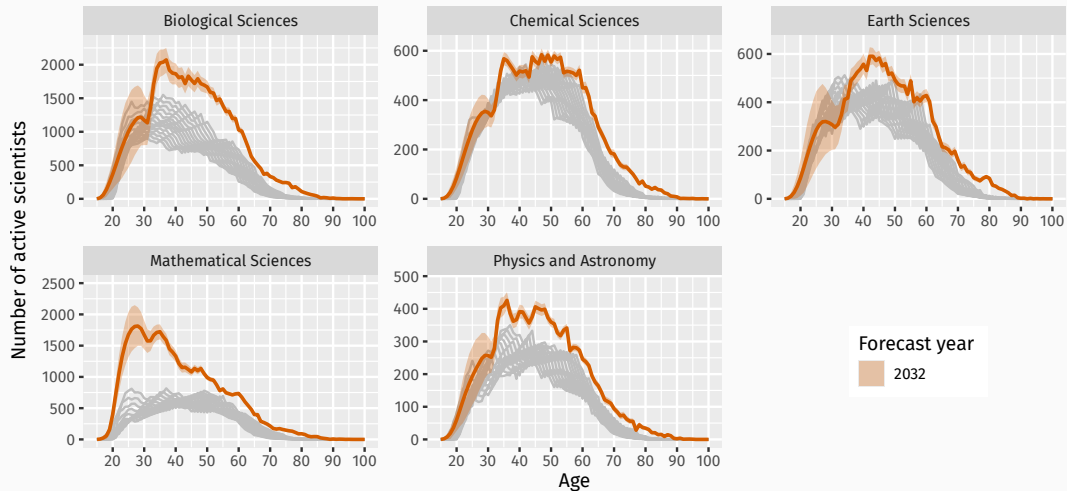
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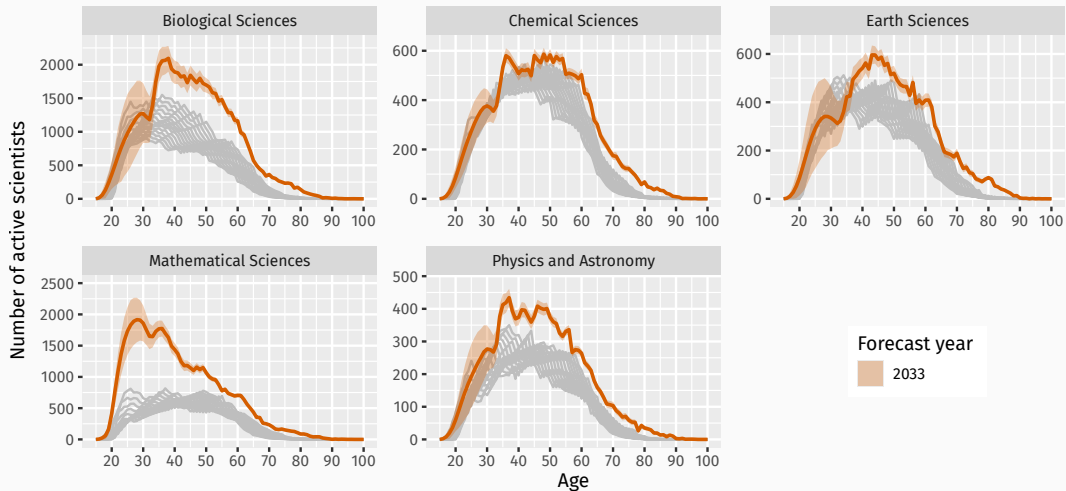
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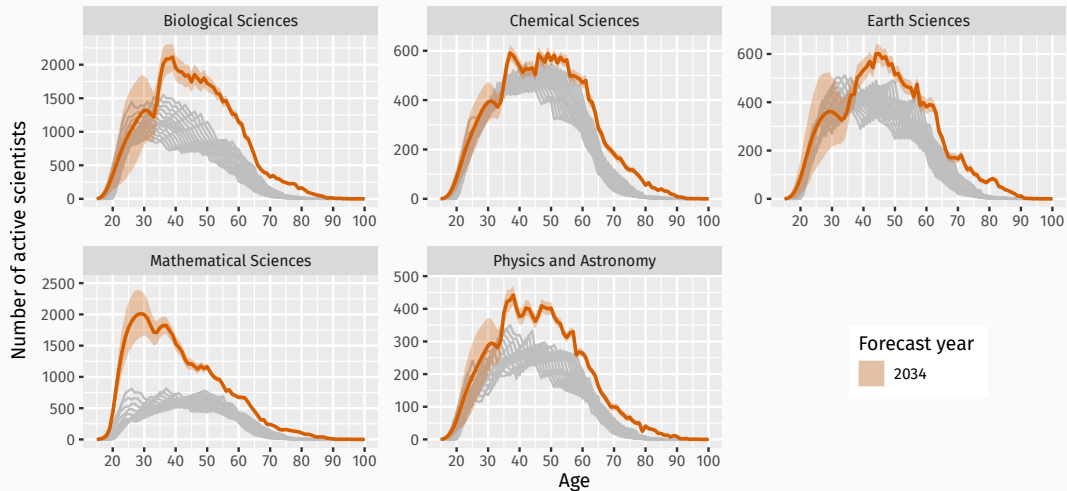
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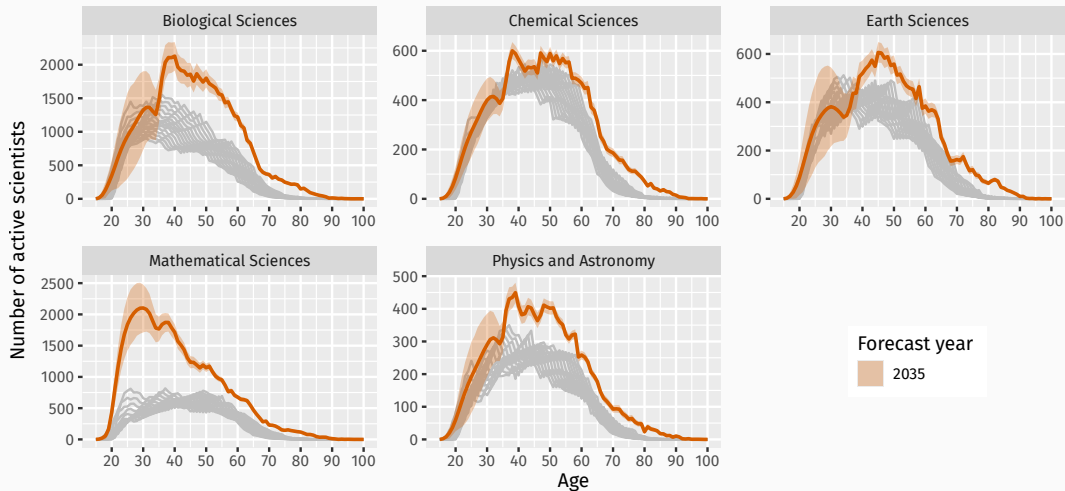
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# Forecasts by discipline

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

Forecast of working population by discipline





## More information



**[robjhyndman.com/asc2025](http://robjhyndman.com/asc2025)**