Bayesian demography 250 years after Bayes

Population Studies 70 (1) 2016: 1–19.

Jakub Bijak & John Bryant

Contents

Preliminaries

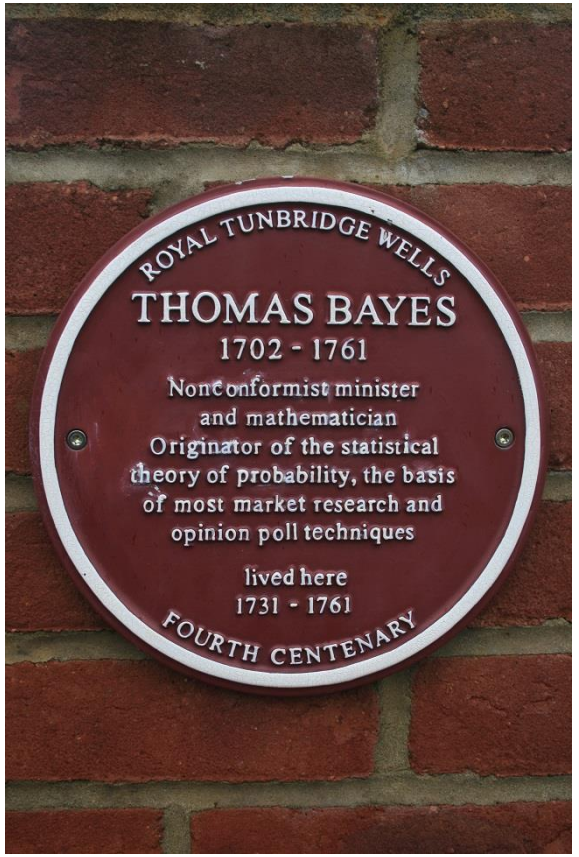
$$p(\text{Unknowns} \mid \text{Data}) = \frac{p(\text{Data} \mid \text{Unknowns}) \times p(\text{Unknowns})}{p(\text{Data})}$$

Source: https://bayesian.org/bayes

- Thomas Bayes (1763†) – special case (binomial)
- Pierre-Simon de Laplace (1812) – general case

http://laplaceinsights.com/about-laplace/

Different philosophical premises than frequentist (likelihood-based) statistics


ROYAL TUNBRIDGE WELLS
THOMAS BAYES
1702 - 1761
Nonconformist minister
and mathematician
Originator of the statistical
theory of probability, the basis
of most market research and
opinion poll techniques
lived here
1731 - 1761
FOURTH CENTENARY

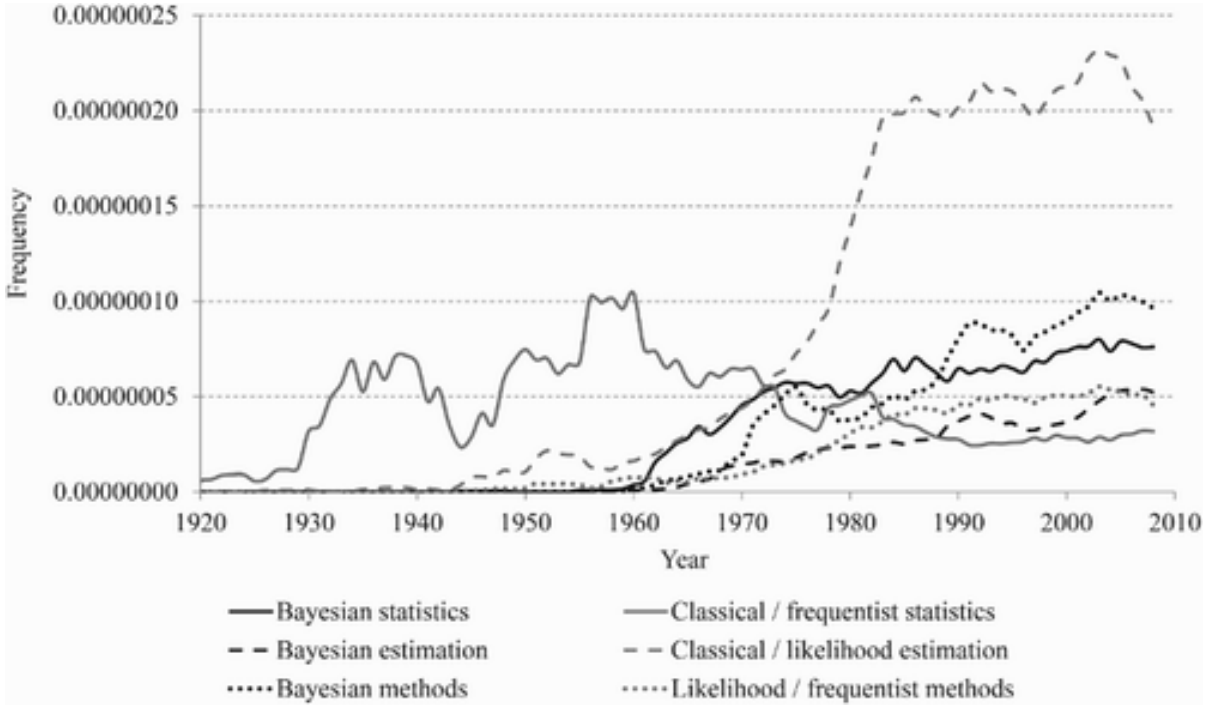
Bayesian controversies?

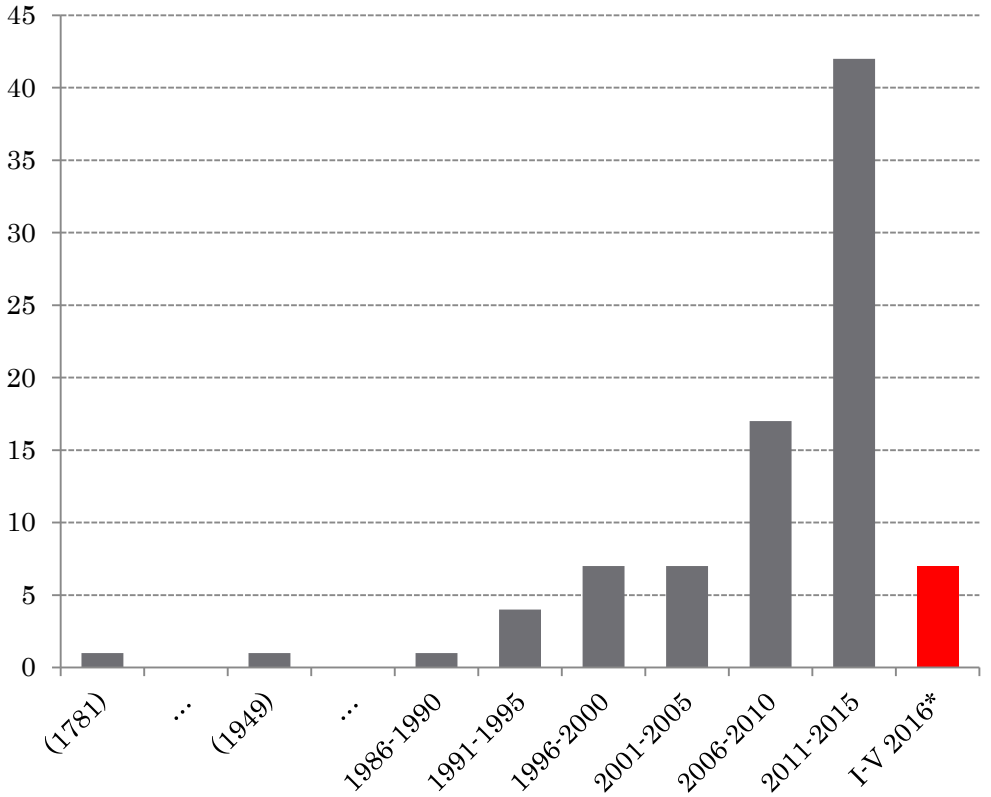
- **Subjectivity vs 'objectivity'**
- Prior vs data trade-offs
- Potential for expert knowledge

- Output: More than point estimates
- Transparent treatment of uncertainty
- A more general framework for other approaches

Trends

Bayesian statistics and Bayesian demography





(Source: Google Ngrams)

Uncertainty in demography

- **Recognised since 1970s, current momentum**
- Forecasts as one of key demographic products
- Small-area estimates with inevitable errors
- New challenges: big data, complex models…

Forecasts

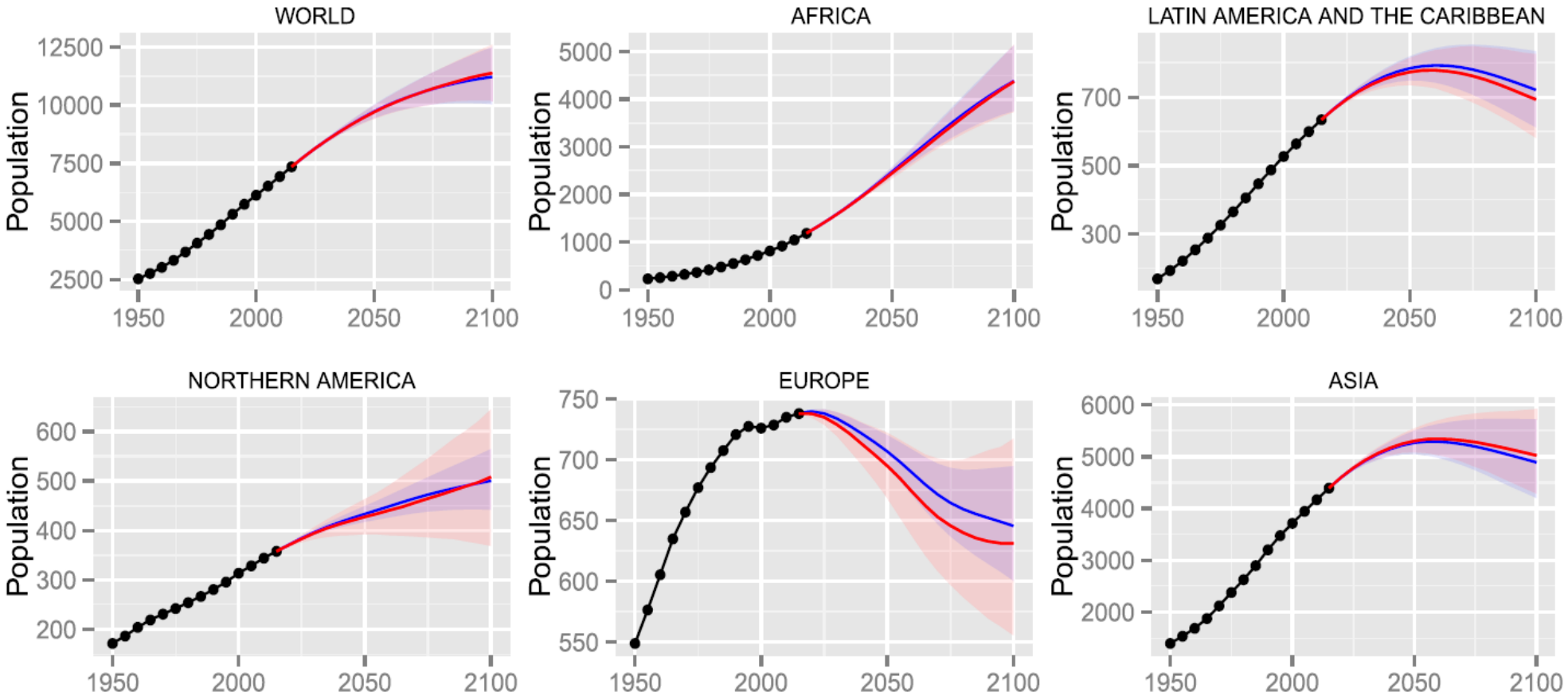


Fig. 2. Regional population projections (in millions) with median projections and 80% prediction intervals. Projections including probabilistic migration projections shown in red, and projections with deterministic migration projections in blue.

Azose et al. (2016) *PNAS* 113, p6462.

Forecasts

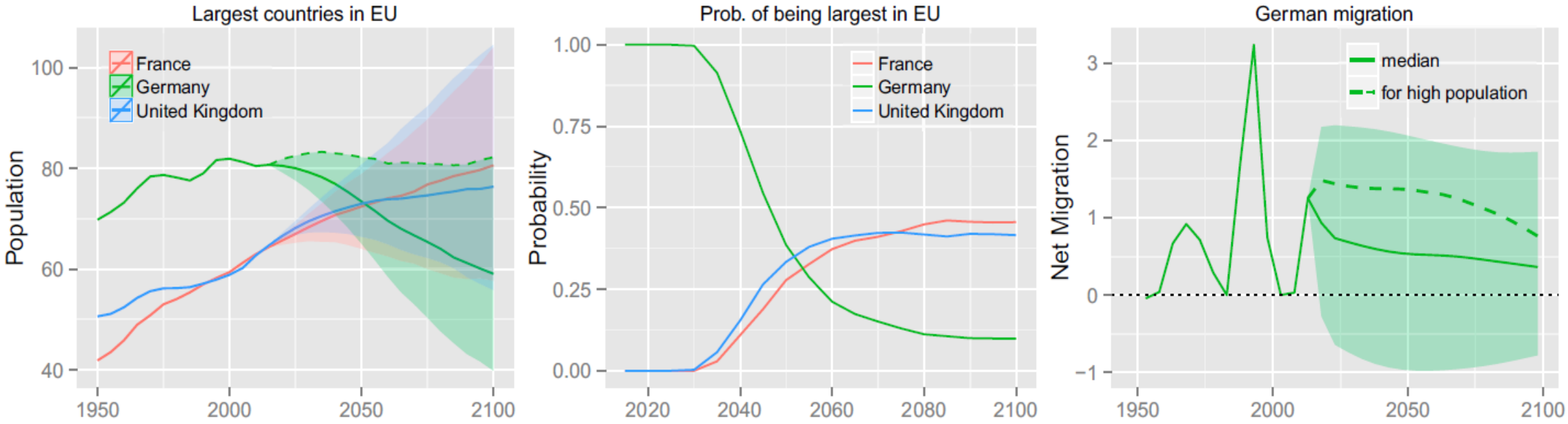
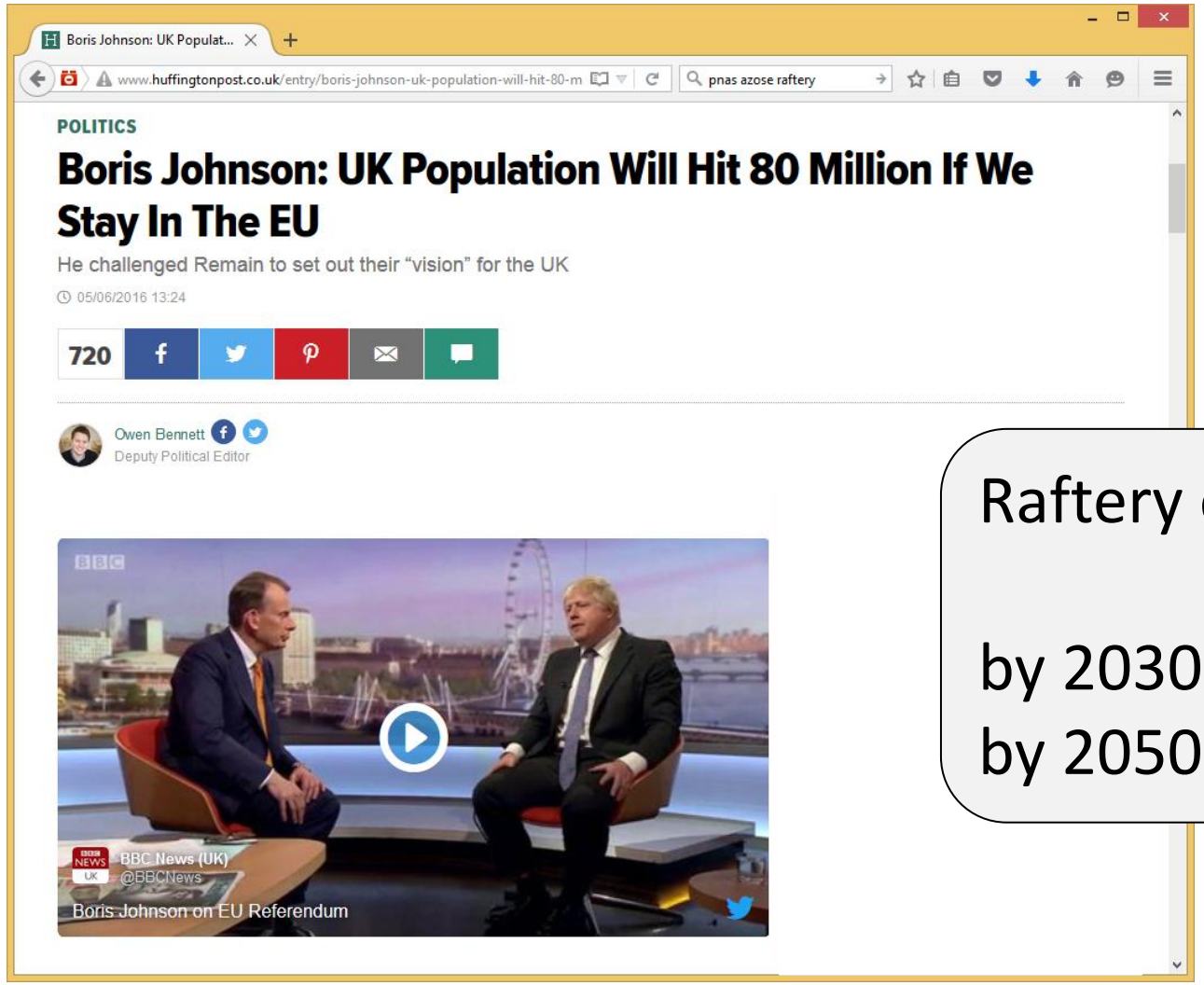


Fig. 3. (*Left*) Population (in millions) of France, Germany, and the United Kingdom, with median projection and 80% prediction interval. (*Center*) Projected probabilities of being the largest of the current European Union (EU) member states. (*Right*) Net migration (5-year count, millions of migrants) for Germany. From 2020 to 2100, median (solid line) and 80% prediction interval (shaded area). Dashed line is the median net migration among trajectories that match the upper bound of the 80% prediction interval for Germany's population shown as dashed line in (*Left*).

Azose et al. (2016) *PNAS* 113, p6463.

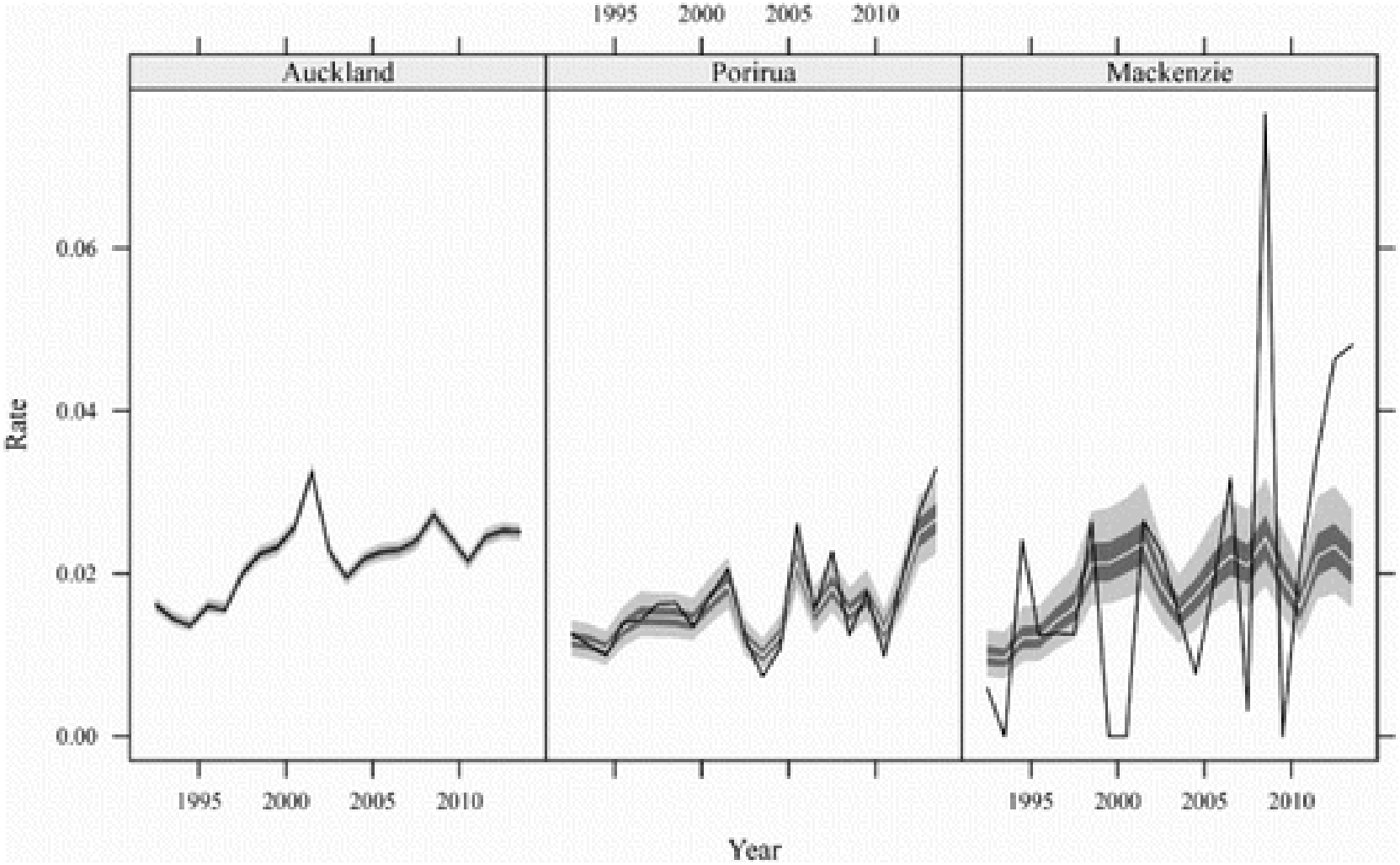
Forecasts



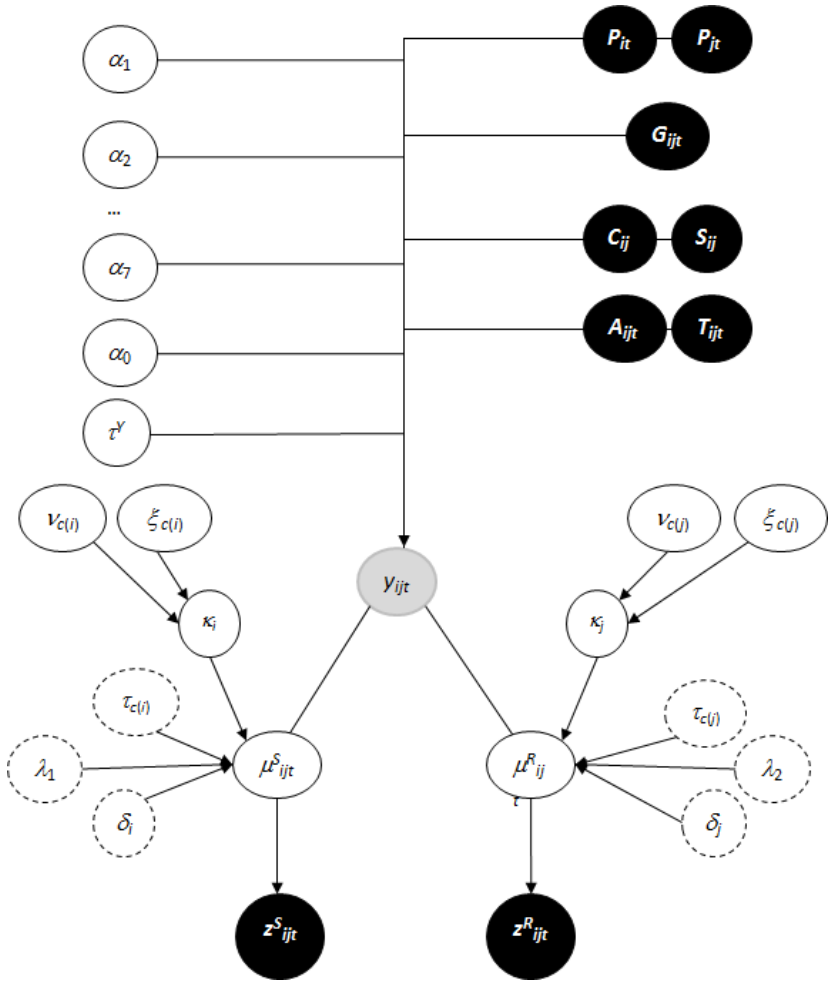
Raftery et al. (2016) :

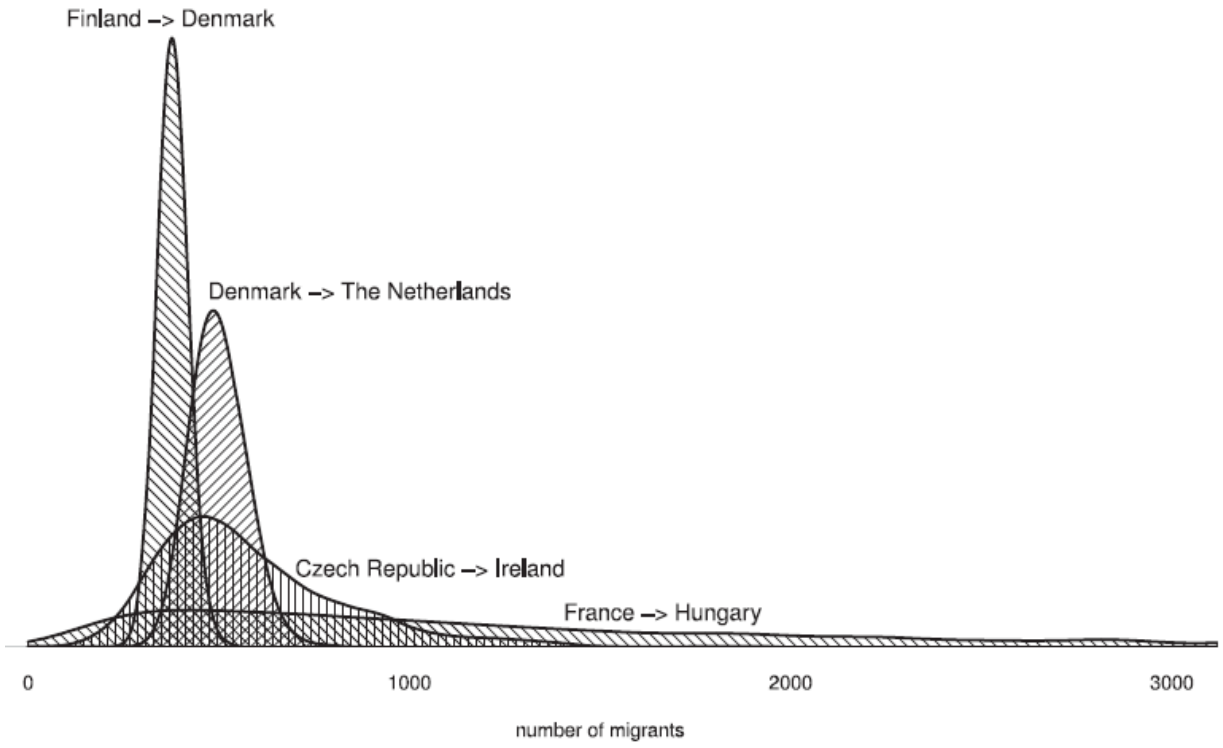
by 2030 – probability less than 0.1%
by 2050 – probability less than 2%

Limited data



Hierarchical and structured models

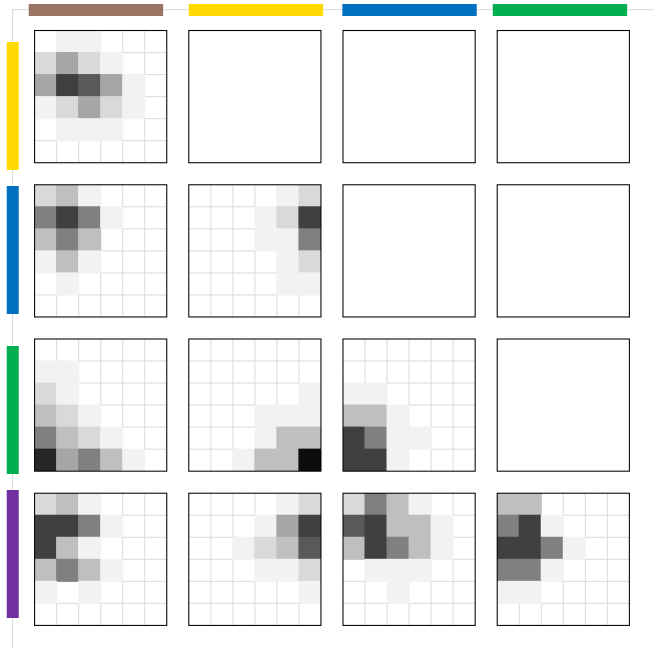




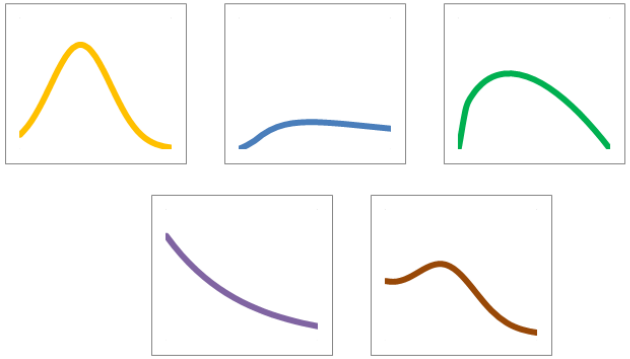
Raymer et al. (2013) *JASA* 108, p804 & 811.

Complex models

Calibration



Uncertainty Analysis

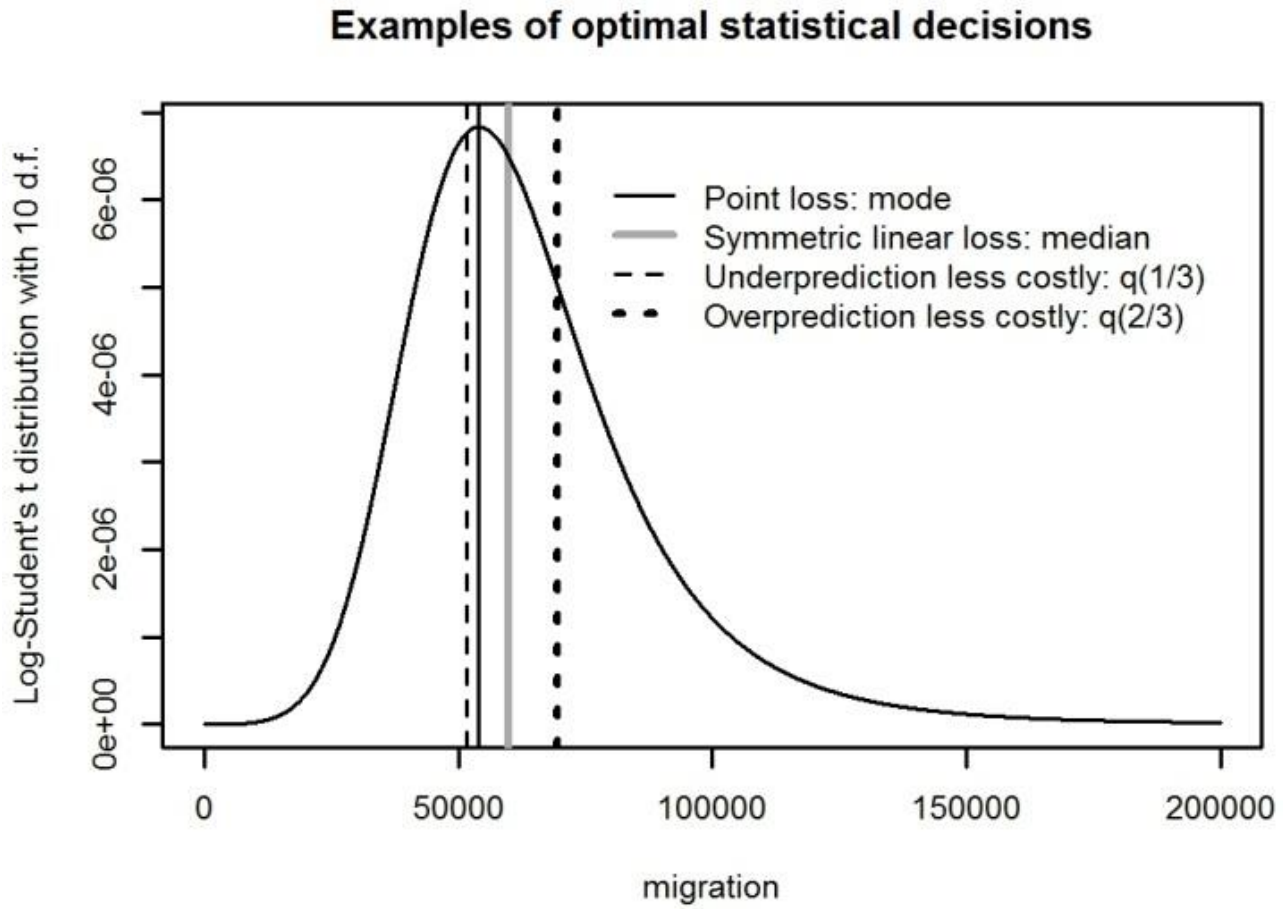


Sensitivity Analysis

Perspectives

- Risk and uncertainty
- Complex modelling
- Big Data
- Decisions

Decisions



Bijak (2010), p226

Challenges

- Training
- Computation
- **Communication**

Thank you!

See also:
https://www.youtube.com/watch?v=WSmbUuxywws

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