Modelling net demand across two area systems for resource adequacy assessment using extreme value methods

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Motivation

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- Security of supply calculations must take into account interconnectors to other system
- Statistical dependence might exist between power availability in different systems.

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- Usual risk metrics:
  - Loss of load expectation (LOLE): $\mathbb{E}[\sum_t \mathbb{I}(M_t < 0)]$
  - Expected energy unserved (EEU): $\mathbb{E}[\sum_t \max\{-M_t, 0\}]$

Estimating the net demand distribution

- **'hindcast' approach**: Use empirical distribution function of historic data:

$$\hat{F}_{D-W}(y) = \frac{1}{n}\sum_{t=1}^{n} \mathbb{I}(d_t - w_t \leq x), \quad y \in \mathbb{R} \tag{2}$$

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- Advantages:
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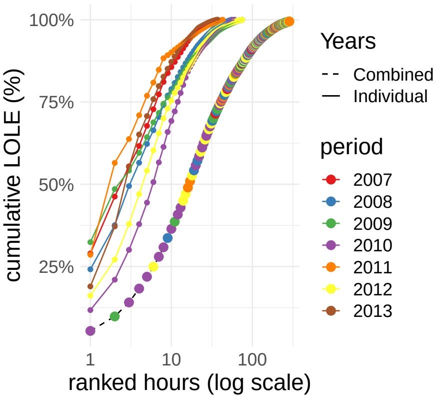
  - Allows exact calculation of metrics
- Drawbacks:
  - risk estimates are determined by very few observations

Hindcast risk estimates



(a) LOLE concentration (GB)

Extreme value theory (EVT) net demand model

- EVT offers mathematically principled models for extrapolation of a distribution's tails.
  - The one-dimensional case has a closed form solution: for a distribution $F(x)$ and large x

$$F(x) \approx \exp\left\{-\left[1+\xi\left(\frac{z-\mu}{\sigma}\right)\right]^{-1/\xi}\right\}$$

  - for some values of μ, σ, ξ

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- A univariate version of this model was used for the GB system by Wilson & Zachary[1]

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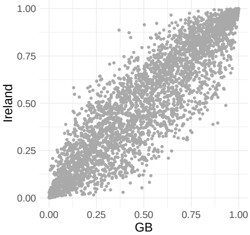
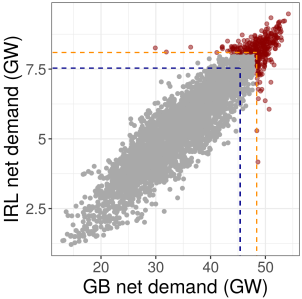
- The logistic model is good for data with symmetric dependence
- We can see this symmetry in the data copula



(a) net demand copula data

Fitted model

- We can now simulate from the extrapolated tails
  - We sample from the logistic model with some probability (say, 5%. Depends on model thresholds), and from the empirical distribution otherwise.



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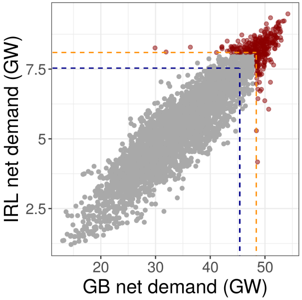

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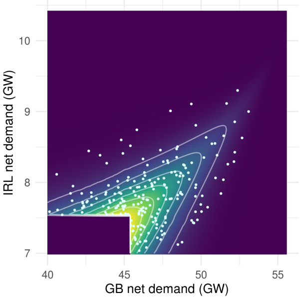
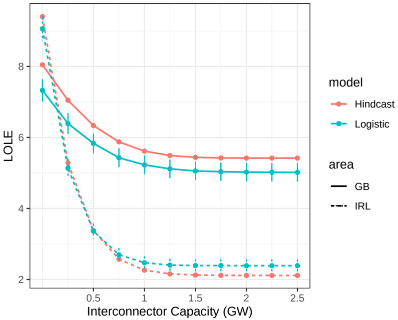


(b) training data + fitted model density

Model comparison

- We can get Monte Carlo risk estimates from the model



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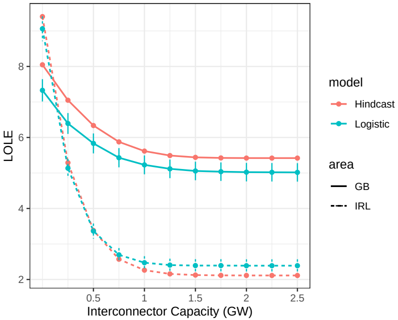

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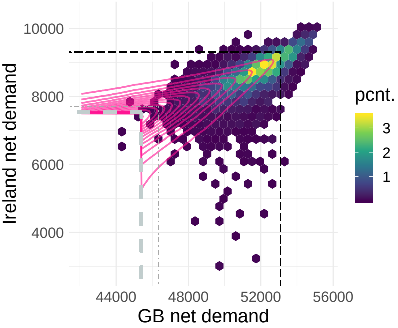

(b) Risk heatmap from logistic model

Conclusions

- ‘Hindcast’ estimates are determined by just a few points $\implies$ they might suffer from high variance
- EV models might help us get more robust risk estimates
- There are still things to analyse before results are complete:
  - sensitivity to model parameters
  - when do both models agree/disagree and why?