Institut für Finanz- und Aktuarwissenschaften ifa

Identifying the Determinants of Lapse Rates in Life Insurance: an automated LASSO approach

IME Congress 2021

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- joint work with Andreas Reuß and Johannes Schupp

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Interactions

Conclusion

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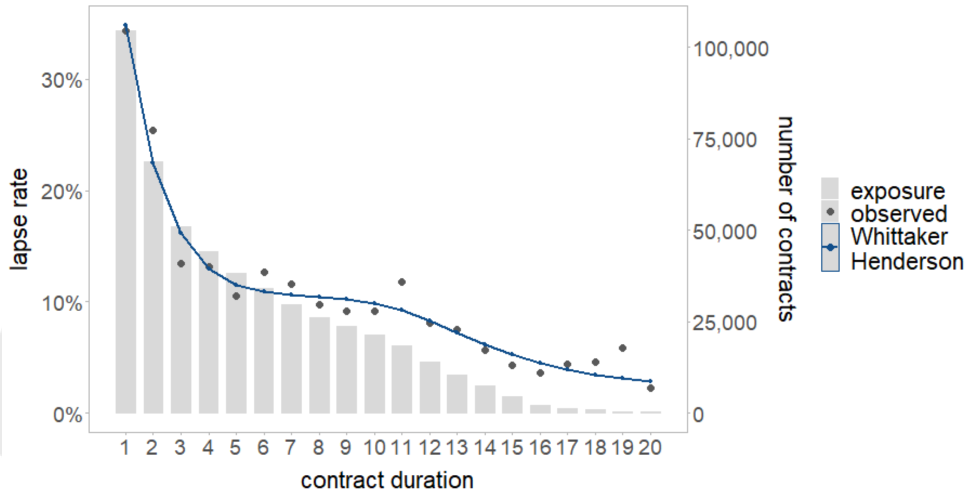
Introduction

Motivation and Common practice

- Lapse risk is one of the key risk drivers of life and pension business.
  - significant impact on the cash flow profile and the profitability of life insurance business
    - relevant for Asset-Liability-Management and liquidity risk
  - Market consistent valuations are based on best estimate future lapse rates.
    - e.g. Solvency II regulation (also specific risk module that addresses lapse risk)

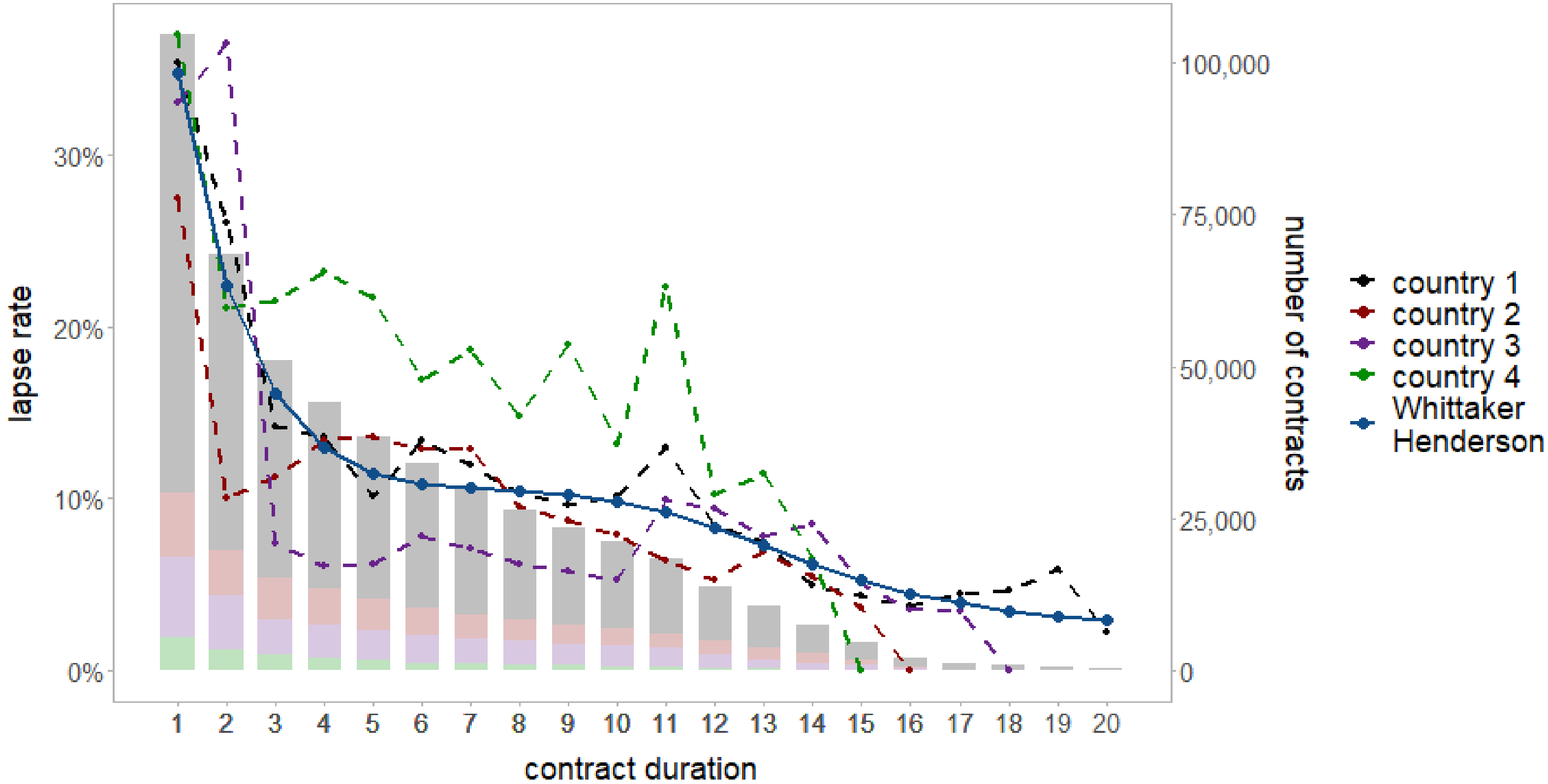
- Common practice
  - Whittaker-Henderson (univariate smoothing algorithm)
  - Prespecified covariate (e.g. contract duration)



Introduction

Whittaker-Henderson

- The insurance portfolio is typically divided into sub-portfolios based on contract characteristics like type of contract, country, or distribution channel.
- Whittaker-Henderson including covariate country



Introduction
Motivation and data set

- Multivariate models estimate lapse rates using all covariates simultaneously.
- GLM lapse model: Eling and Kiesenbauer (2014) and Barucci et al. (2020)
  - number of coefficients → considerable effort
  - risk of under- or overfitting
- Data Science methods can be a solution. We use the LASSO approach to derive a lapse model that
  - is calibrated automatically and purely data driven,
  - but remains fully interpretable,
  - is able to detect hidden structures in the covariates.
- We analyze and combine different extensions of LASSO to satisfy the needs of a practical application.
- Application
  - We use data from a European life insurer operating in four countries (run-off portfolio).
  - We use 13 covariates and a total sample size of 501,251.
  - covariates include standard data of an insurance company, e.g.:
    - contract duration, entry age, sum insured, country, contract type,…

Method
Logistic regression and LASSO

- Logistic regression
  - Y_i is Bernoulli distributed.
  - $E(Y_i) = p(x_i)$
  - Transform $p(x_i)$ and assume a linear relationship:

$$\text{logit}\big(p(x_i)\big) = \ln\left(\frac{p(x_i)}{1 - p(x_i)}\right) = \beta_0 + \beta_1 x_{i1} + \ldots + \beta_m x_{im}$$

  - Likelihood function:

$$L(\beta, X, y) = \prod_{i=1}^{n} p(x_i)^{y_i} (1 - p(x_i))^{(1 - y_i)}$$

- LASSO (Least Absolute Shrinkage and Selection Operator)
  - Include a regularization term:

$$\min \quad -\log\big(L(\beta, X, y)\big) + \lambda \sum_{j=1}^{J} g(\beta_j)$$

Shrinkage-Factor: $\lambda \geq 0$
Controlling the impact of regularization and goodness-of-fit

Regularization:
Penalty term for the coefficients
Regular Lasso: $g(\beta_j) = \sum_{i=1}^{p_j} |\beta_{j,i}|$

Method

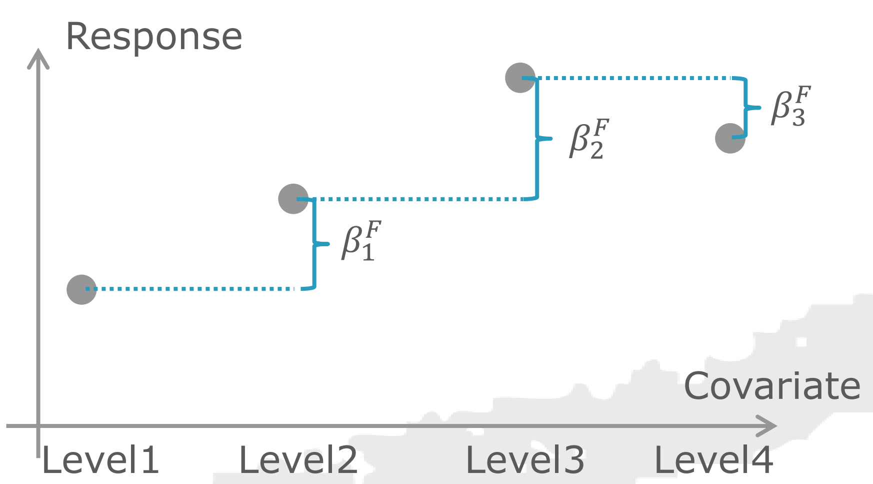
Extension: Fused LASSO and Trend Filtering - Tibshirani and Taylor (2011)

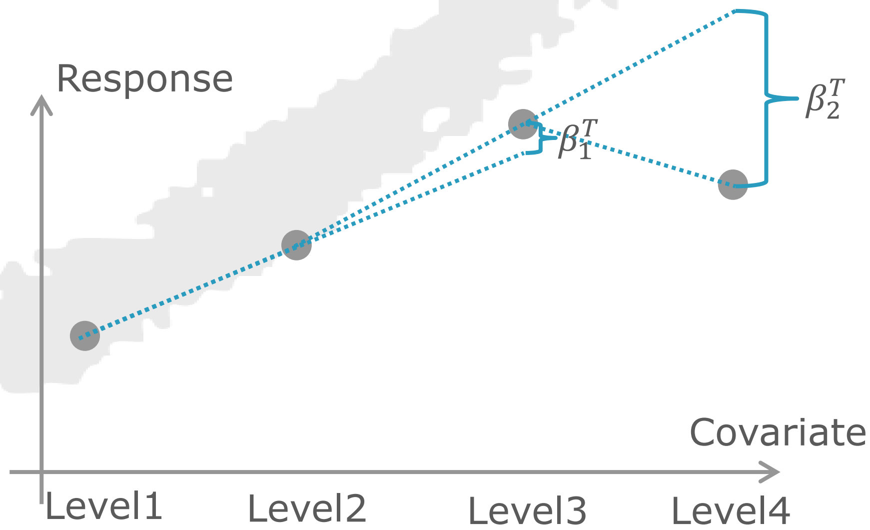
- Now we extend the LASSO: $\min \quad -\log\big(L(\beta, X, y)\big) + \lambda \sum_{j=1}^{J} g_j(\beta_j)$ → Devriendt et al. (2018)
  - Regular LASSO: $g_R(\beta_j) = \| \beta_j \|_1 = \sum_{i=1}^{p_j} |\beta_{j,i}|$
  - Fused LASSO:

$$g_F(\beta_j) = \sum_{i=2}^{p_j} |\beta_{j,i} - \beta_{j,i-1}| =: \sum_{i=2}^{p_j} |\beta_{j,i}^F|$$

  - Trend Filtering:

$$g_T(\beta_j) = \sum_{i=3}^{p_j} |\beta_{j,i} - 2\beta_{j,i-1} + \beta_{j,i-2}| =: \sum_{i=3}^{p_j} |\beta_{j,i}^T|$$



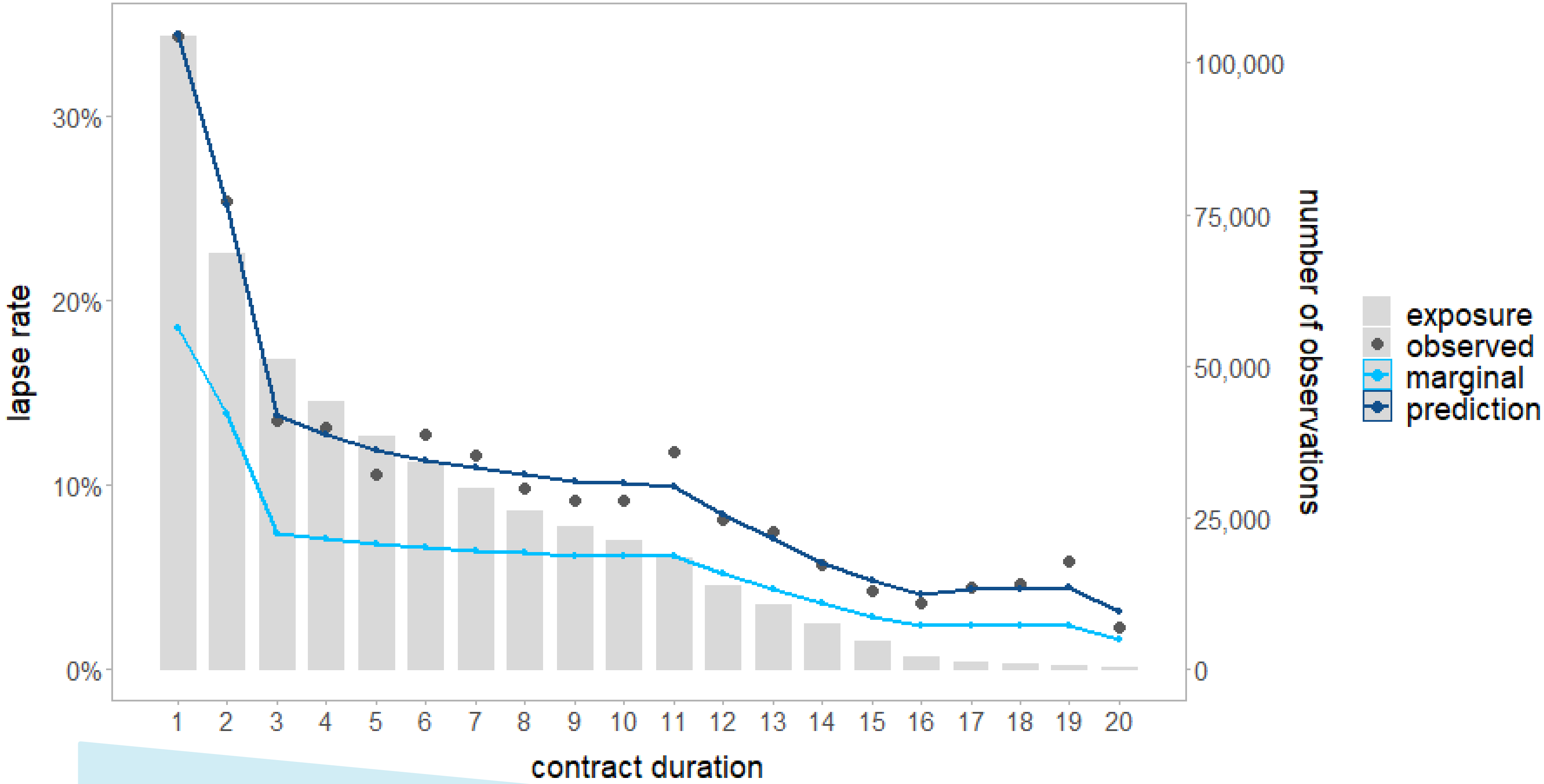


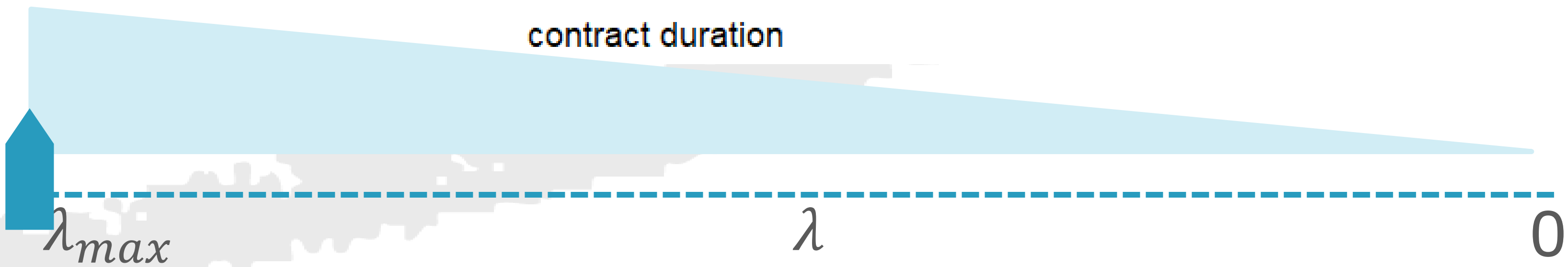
Model Selection

- R interface for H2O
- Assign a penalty term for each covariate:
  - Contract duration → trend
  - Entry age → fused
  - Sum insured → trend
  - Country → regular
  - …
- Hyperparameter λ is based on 5-fold cross validation with one standard error rule.
- Residual Deviance as measure for goodness of fit

Model Selection

Trend filtering for contract duration





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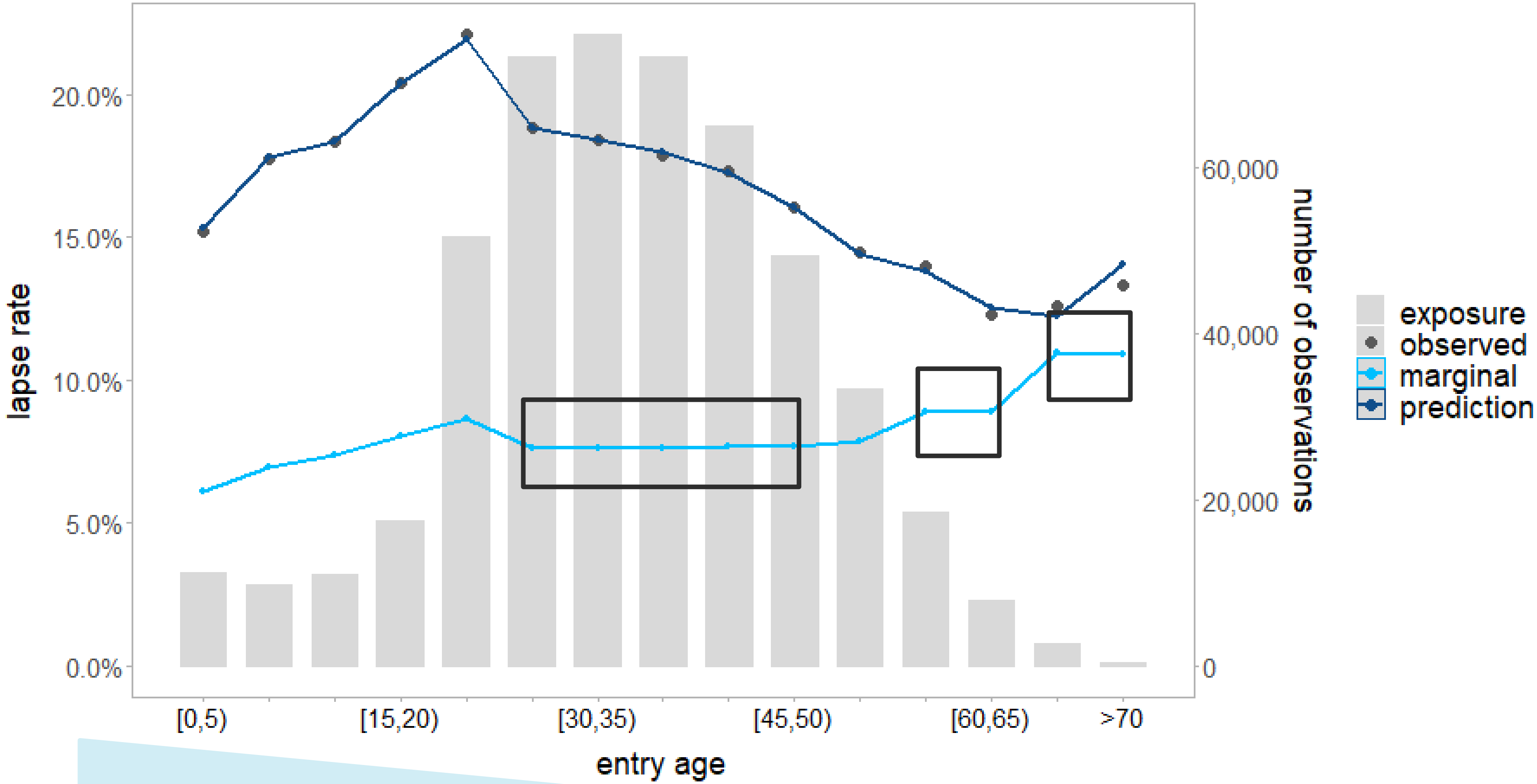
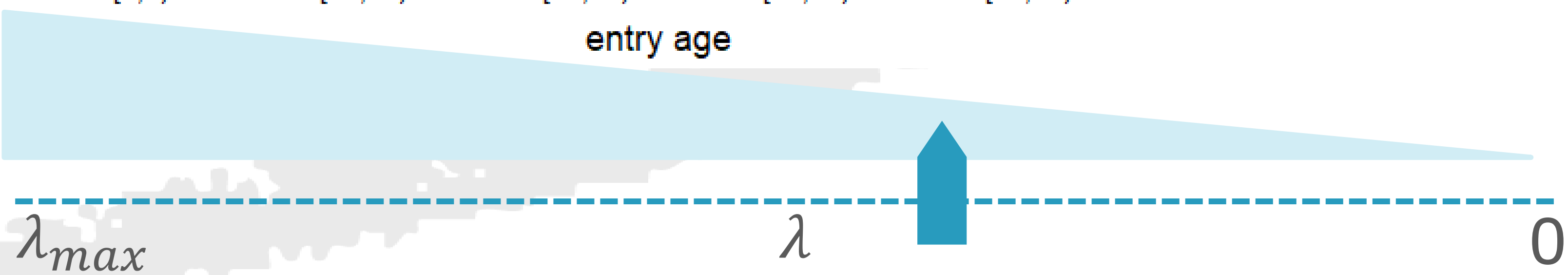
Model Selection

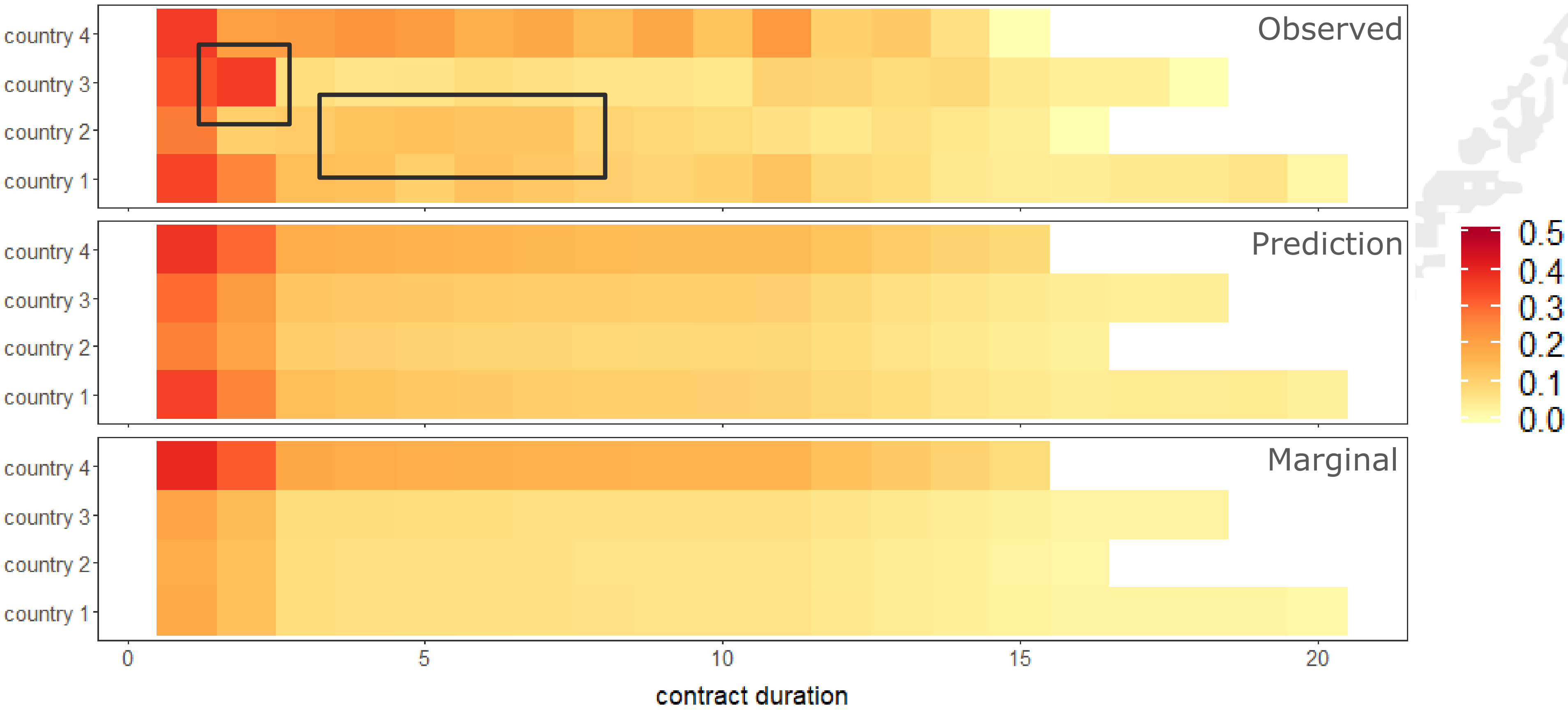
Fused Lasso for entry age





Interactions

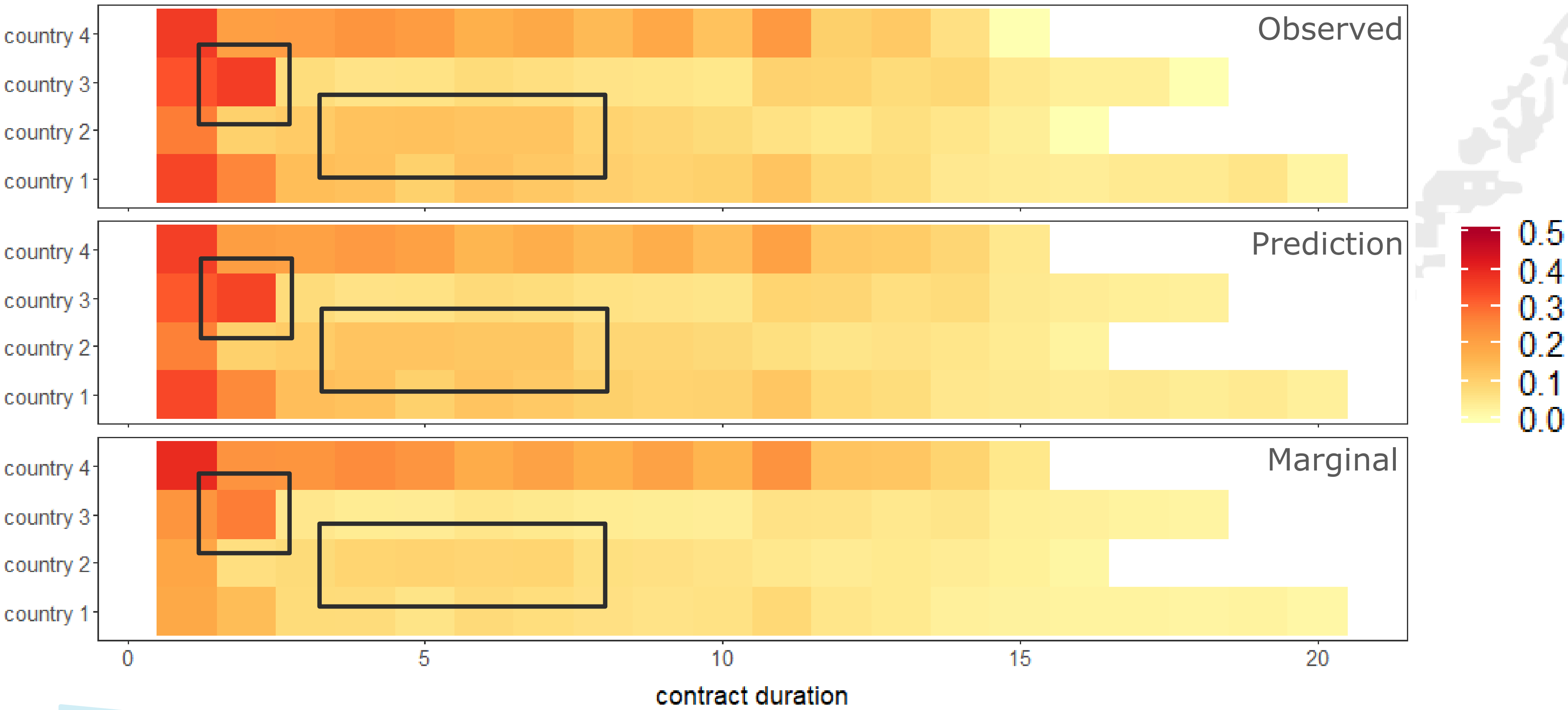
Motivation – Problem of the model without interactions

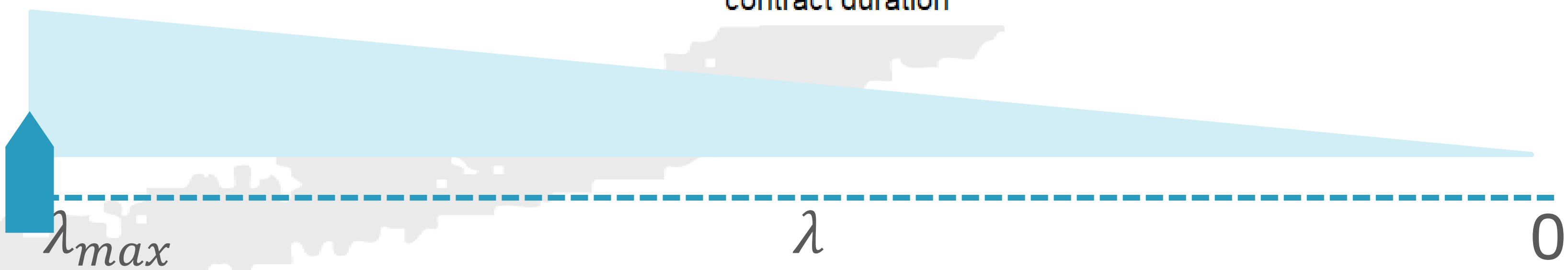


- Impact of contract duration on observed lapse rates differs for the individual countries
- Model without interaction does not capture this
- We want to include the interaction contract duration - country

Interactions

Model with the interaction contract duration - country





Conclusion

- Results:

Model	1 - Deviance/Null Deviance
Intercept Only	0%
Whittaker-Henderson	6.7%
LASSO without interaction	11.0%
LASSO with interaction	11.7%

+64%
+6%

- Advantages - The resulting model
  - is multivariate and estimates lapse rates using all covariates simultaneously,
  - is calibrated automatically and purely data driven,
  - remains fully interpretable,
  - is able to detect hidden structures in the covariates.
- Outlook on further research questions:
  - Offset model
  - Extrapolation
  - Other machine learning algorithms

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