Collinearity in Prognostic Models for Dysphagia

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Compared methods

1. Standard logistic regression (**LR**)
2. **Lasso** penalization
3. **Ridge** penalization
4. **ElasticNet** penalization
5. Principal component analysis logistic regression (**PCLR**)
6. Linear auto-encoder logistic regression (**LAELR**)
7. **Dropout** regularization
8. Non-negative constraints (**LRnn**)

Simulation study

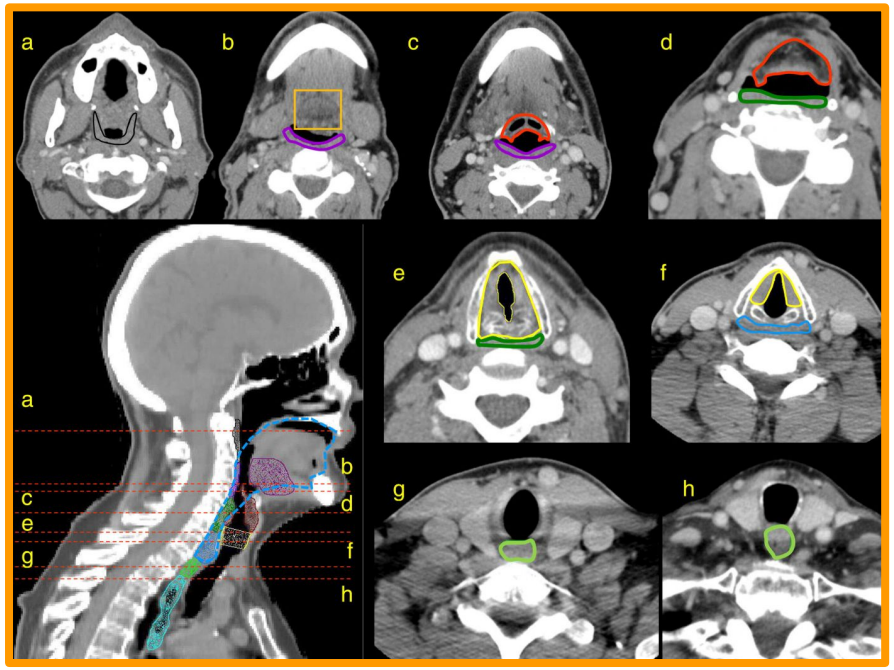
Case study (simulation study):
For **head and neck cancer patients**, we aim to predict the risk of experiencing **complications** 6 months **after radiotherapy**.

Predictors X :

- **Dosage per relevant organ**
- …

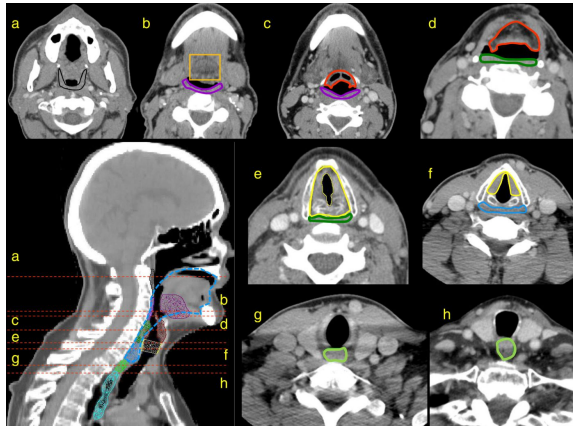
Outcome y:

- Dysphagia M_6



High **collinearity** of dosage for OAR

	AGE	Subm.L.Dm	Subm.R.Dm	Parotid.L.Dm	Parotid.R.Dm	PCM.Sup.Dm	PCM.Med.Dm	PCM.Inf.Dm	Supraglottic.Dm	OralCavity.Ext.Dm	GlotticArea.Dm	DYSFAGIE.BSL.1
Subm.L.Dm	-0.25											
Subm.R.Dm	-0.27	0.88										
Parotid.L.Dm	-0.26	0.85	0.72									
Parotid.R.Dm	-0.28	0.69	0.83	0.74								
PCM.Sup.Dm	-0.28	0.85	0.86	0.82	0.81							
PCM.Med.Dm	-0.25	0.87	0.89	0.74	0.72	0.79						
PCM.Inf.Dm	0.11	-0.11	-0.13	-0.11	-0.12	-0.35	0.11					
Supraglottic.Dm	-0.08	0.36	0.38	0.27	0.27	0.12	0.60	0.69				
OralCavity.Ext.Dm	-0.28	0.83	0.85	0.80	0.80	0.95	0.73	-0.40	0.07			
GlotticArea.Dm	0.15	-0.33	-0.34	-0.31	-0.31	-0.56	-0.16	0.89	0.54	-0.60		
DYSFAGIE.BSL.1	-0.04	0.24	0.25	0.25	0.21	0.24	0.23	-0.06	0.03	0.28	-0.12	
DYSFAGIE.BSL.2	-0.09	0.18	0.17	0.23	0.23	0.17	0.20	0.06	0.13	0.21	-0.01	-0.10



Simulation setup

Two levels of collinearity: **2** settings.

- Multivariate Gaussian to simulate predictor (cov from real data of 750 pts.)
- True predictor–outcome relation: Ridge fit on real data of 750 pts.
- ~600 training samples, 10.000 test samples, 100 repeats

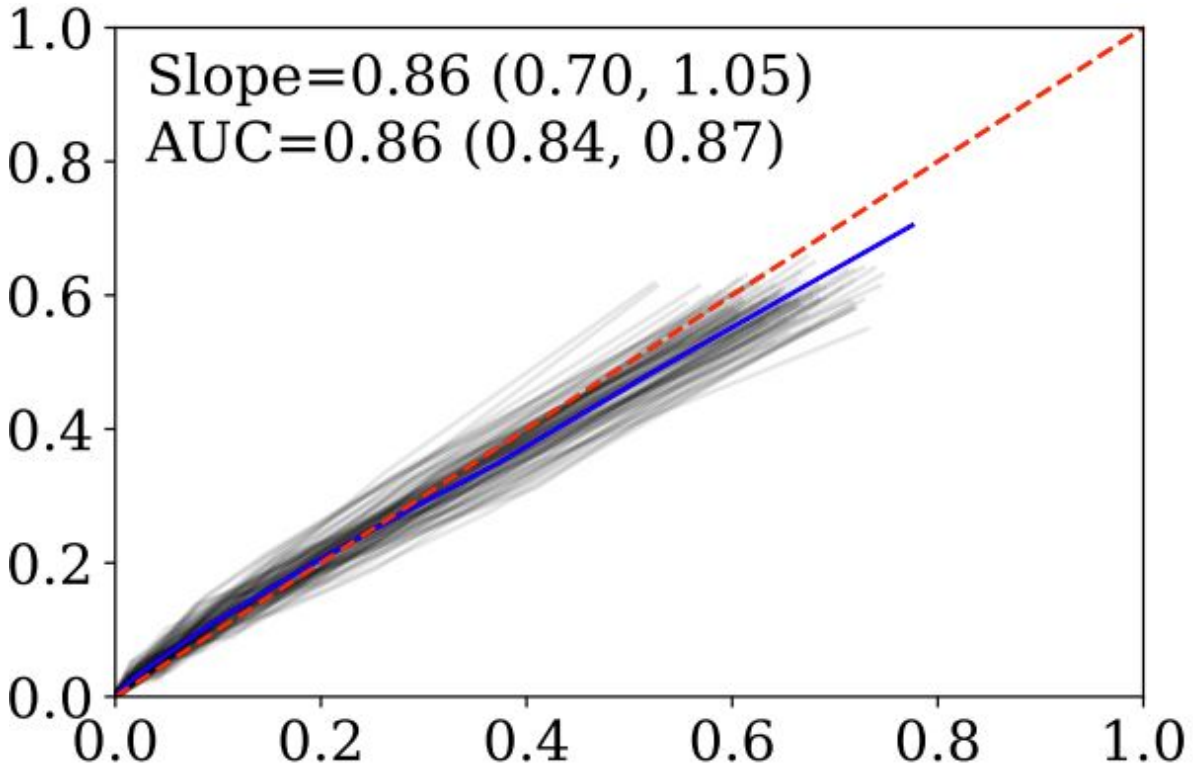
* We only discuss a selection of the studied settings.

Results: spot the differences

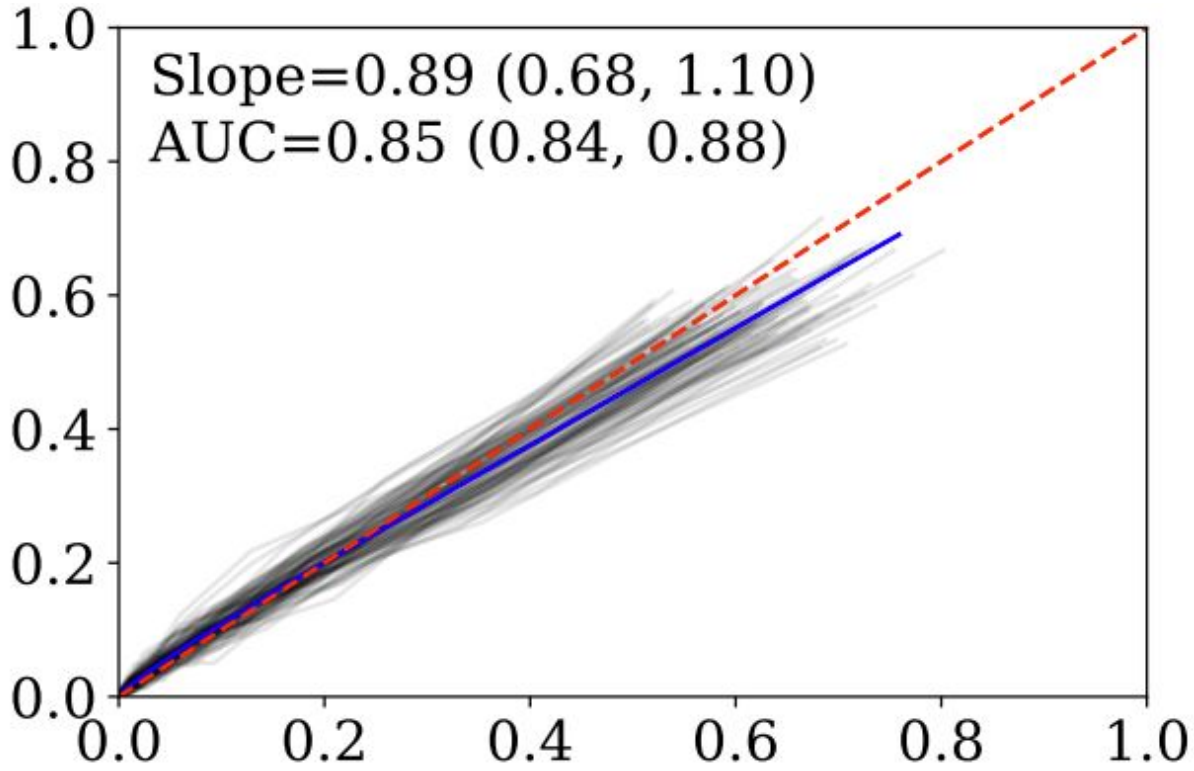
VIF=5 (EPV:6)

VIF=43 (EPV:6)

Results: LR

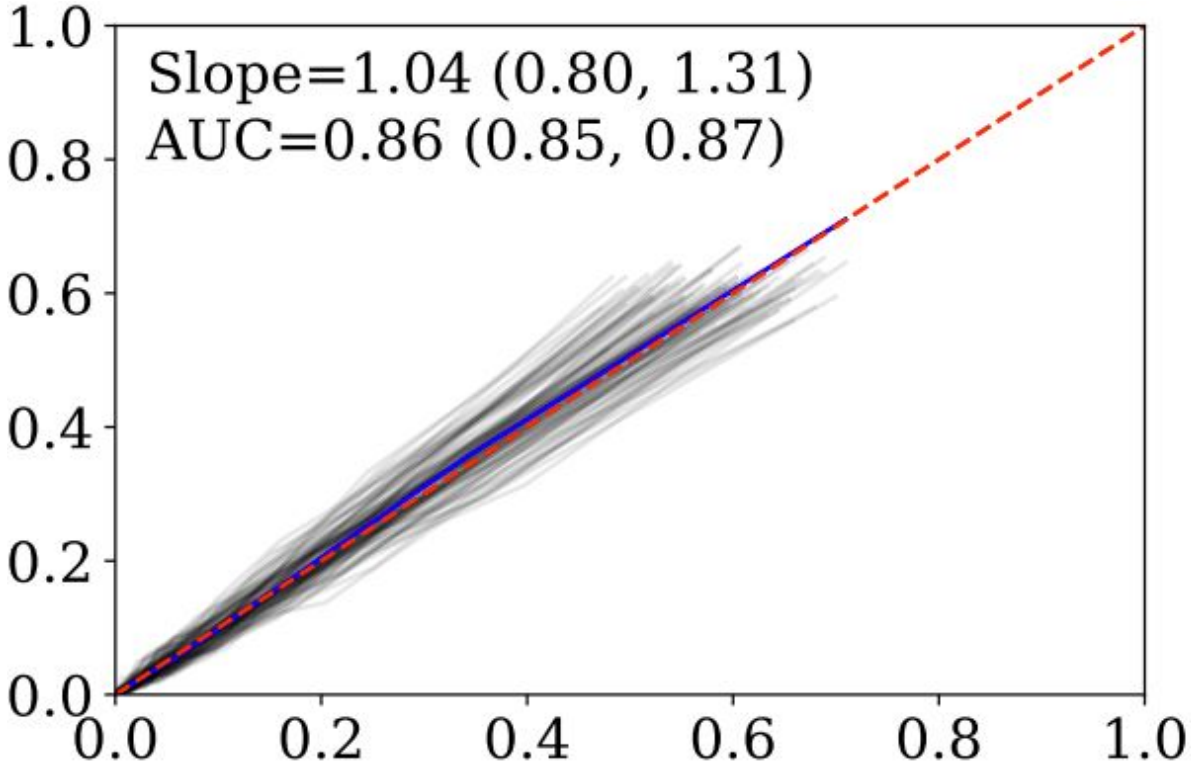


VIF=5 (EPV:6)

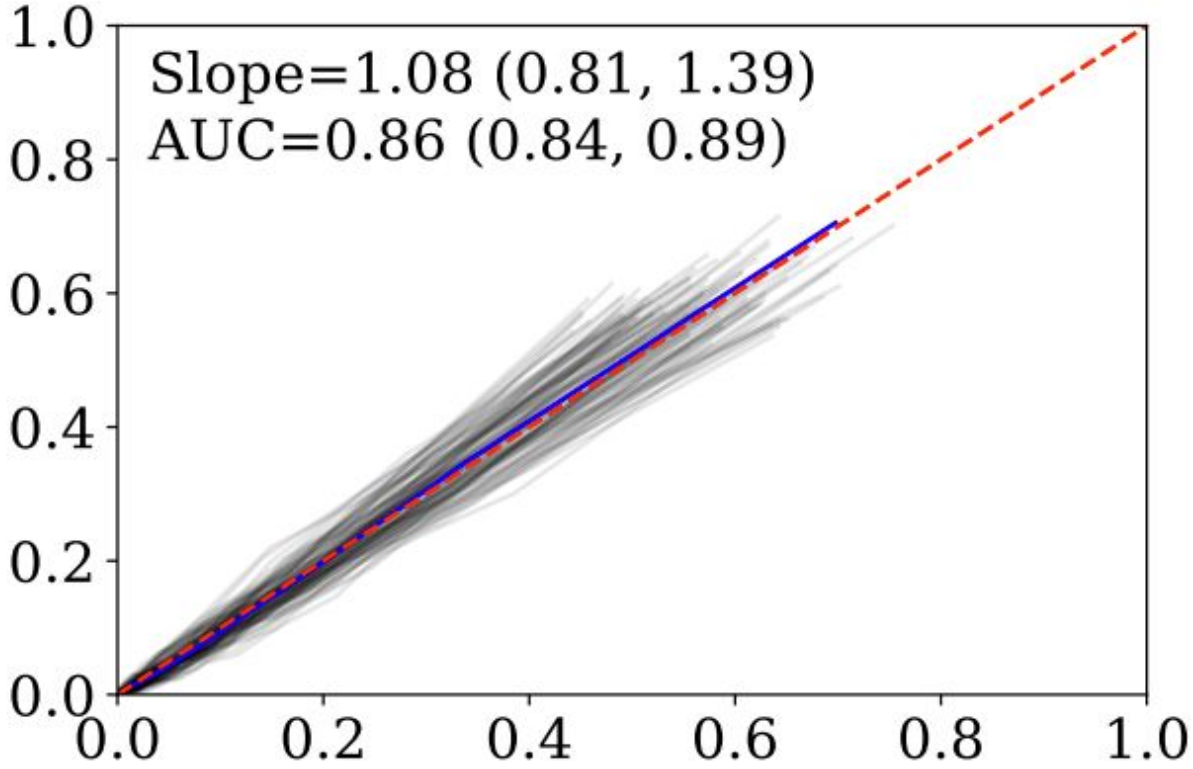


VIF=43 (EPV:6)

Results: Lasso

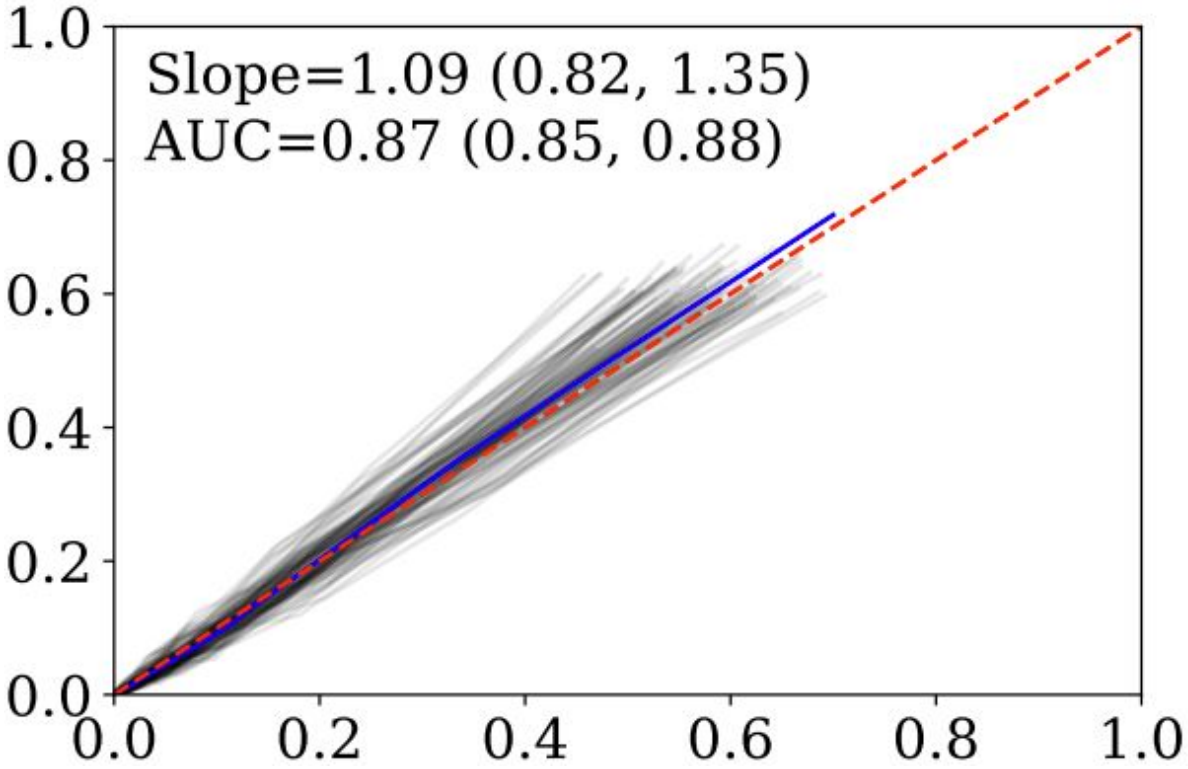


VIF=5 (EPV:6)

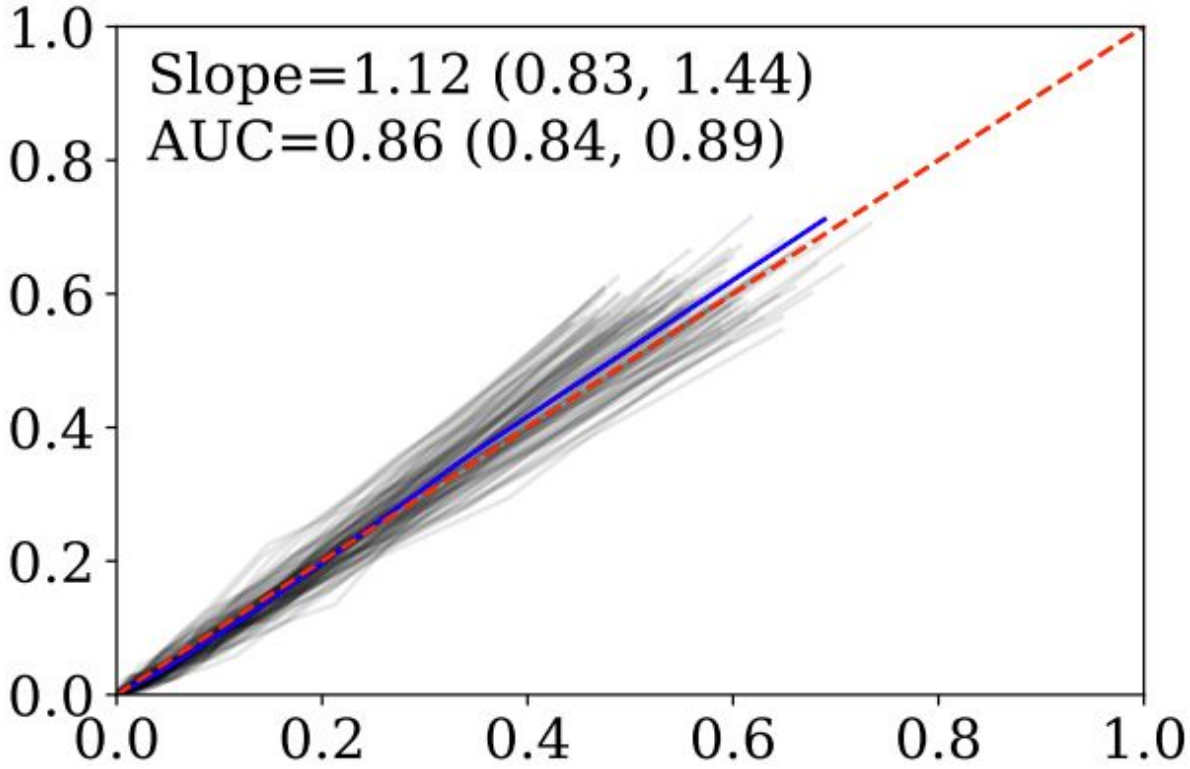


VIF=43 (EPV:6)

Results: Ridge

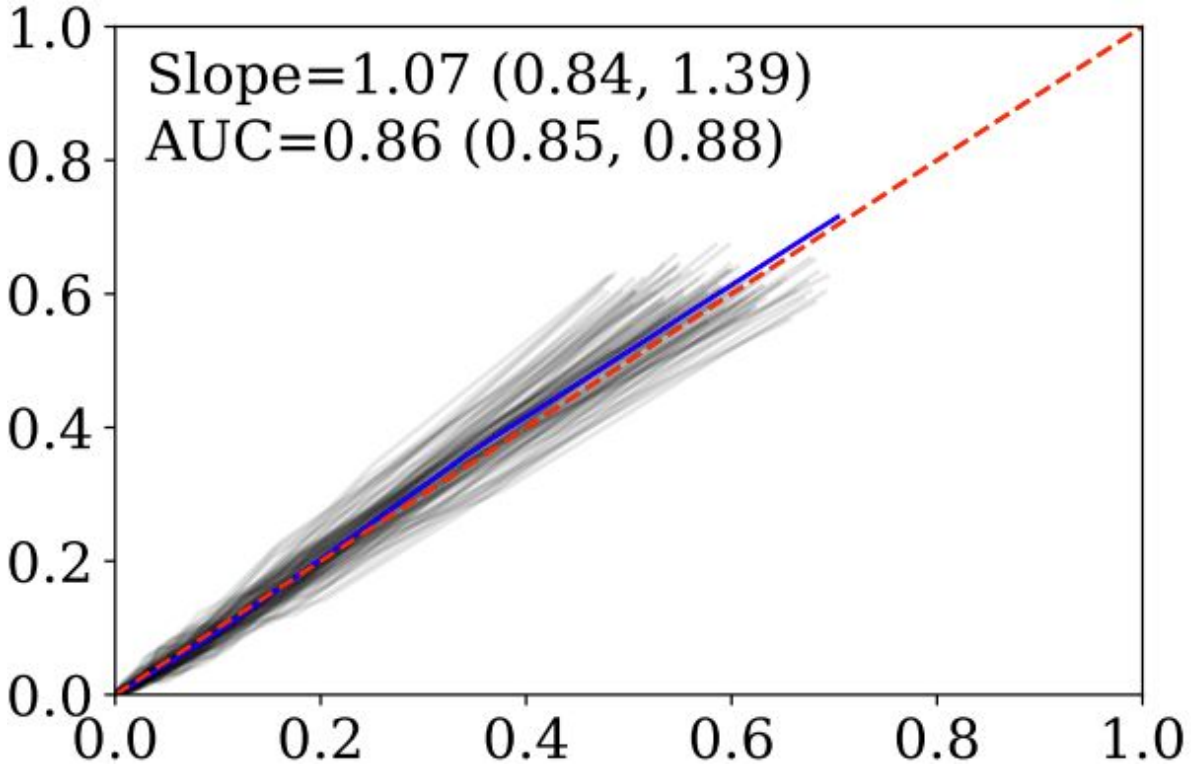


VIF=5 (EPV:6)

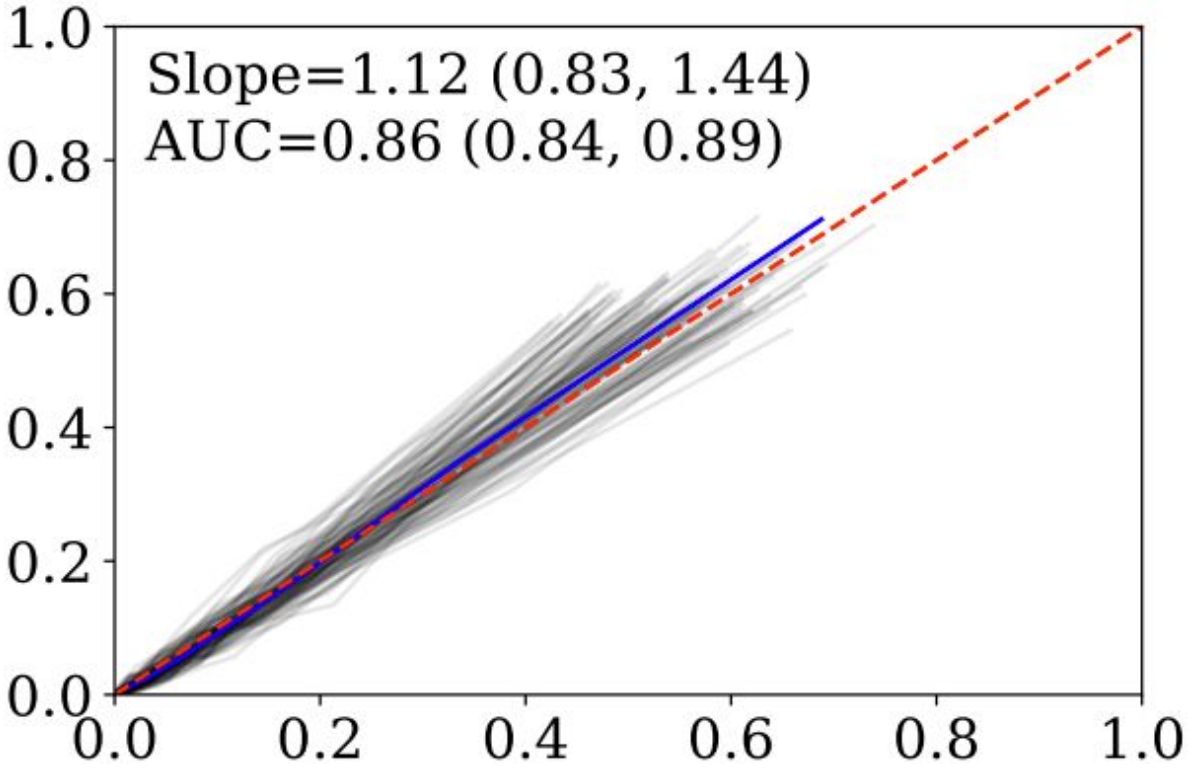


VIF=43 (EPV:6)

Results: ElasticNet

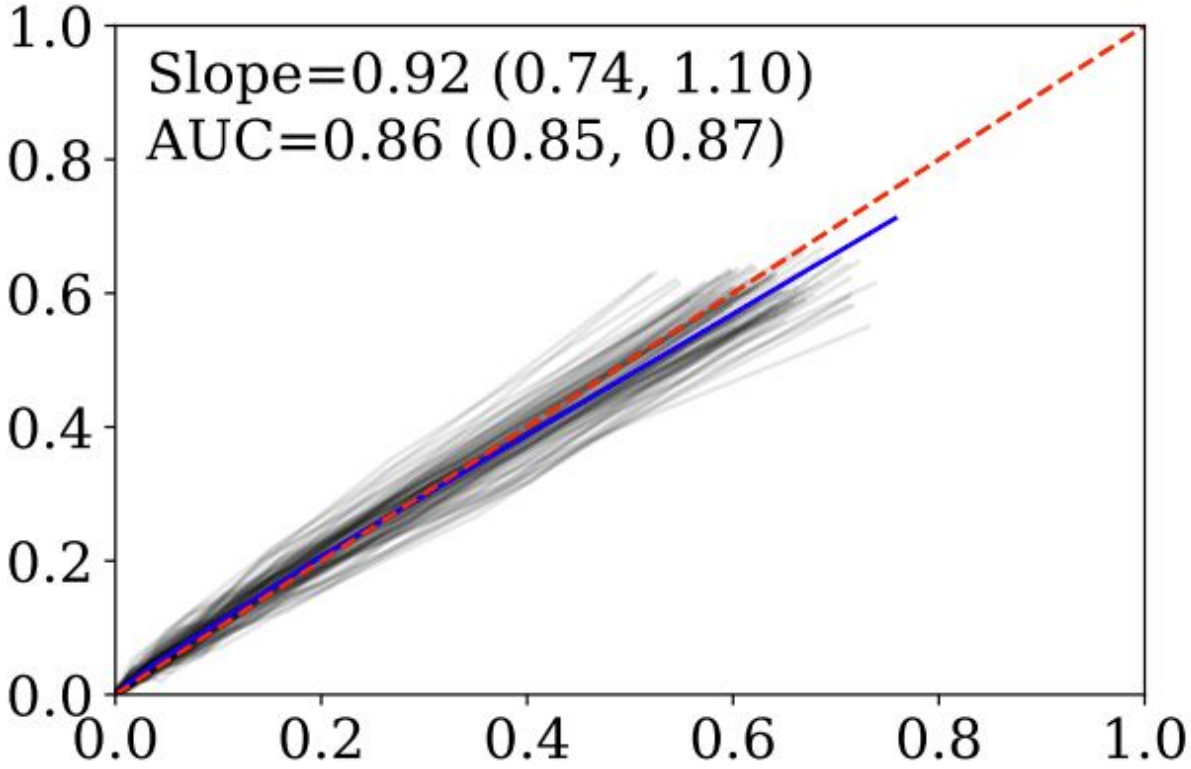


VIF=5 (EPV:6)

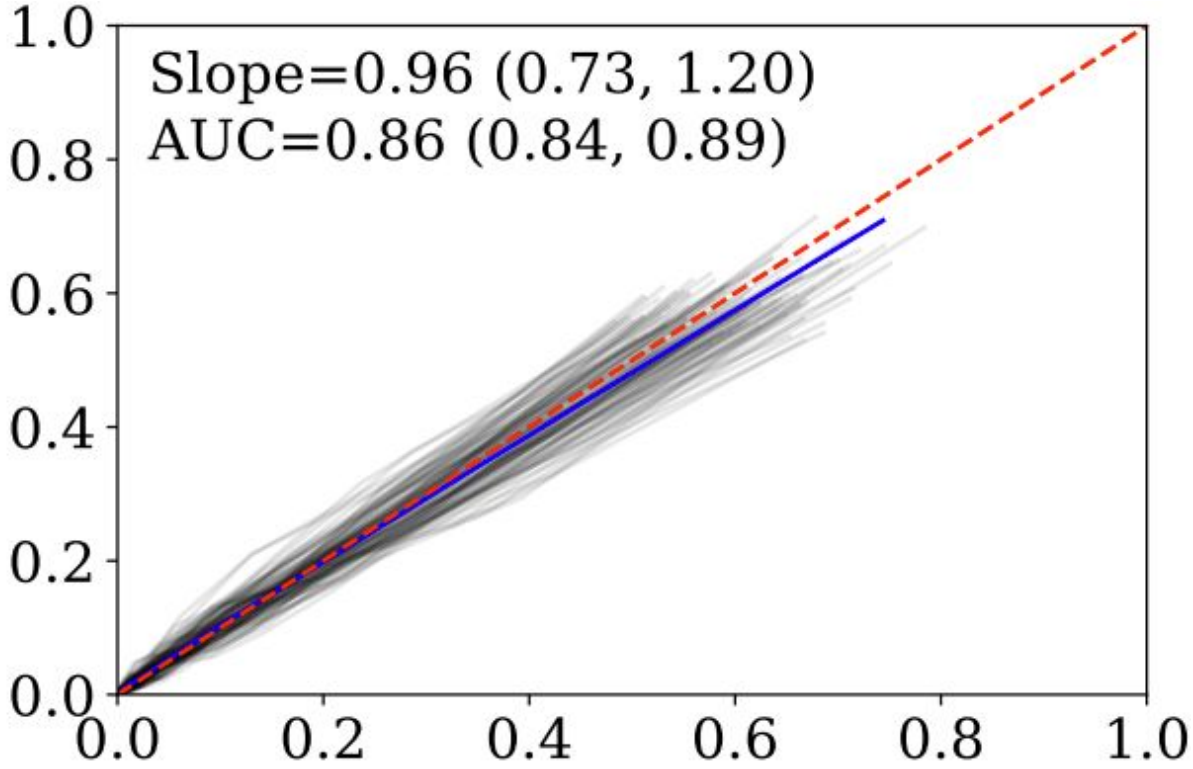


VIF=43 (EPV:6)

Results: PCLR

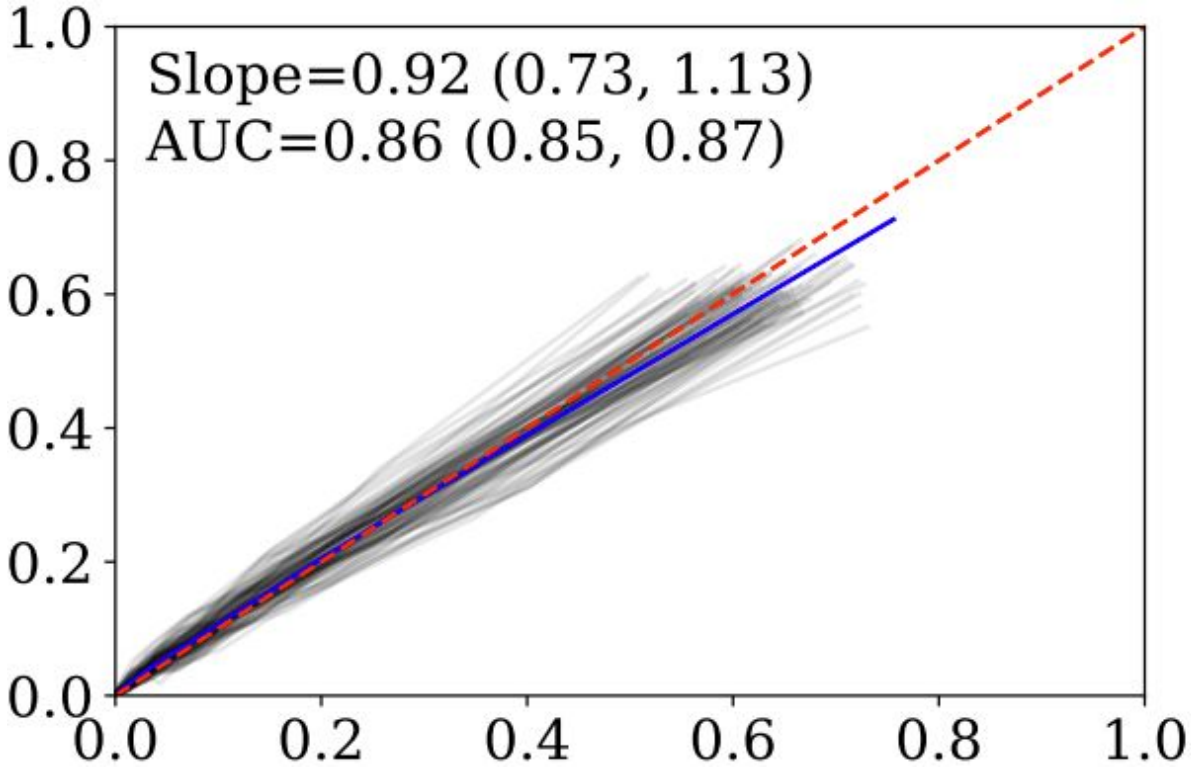


VIF=5 (EPV:6)



VIF=43 (EPV:6)

Results: LAELR



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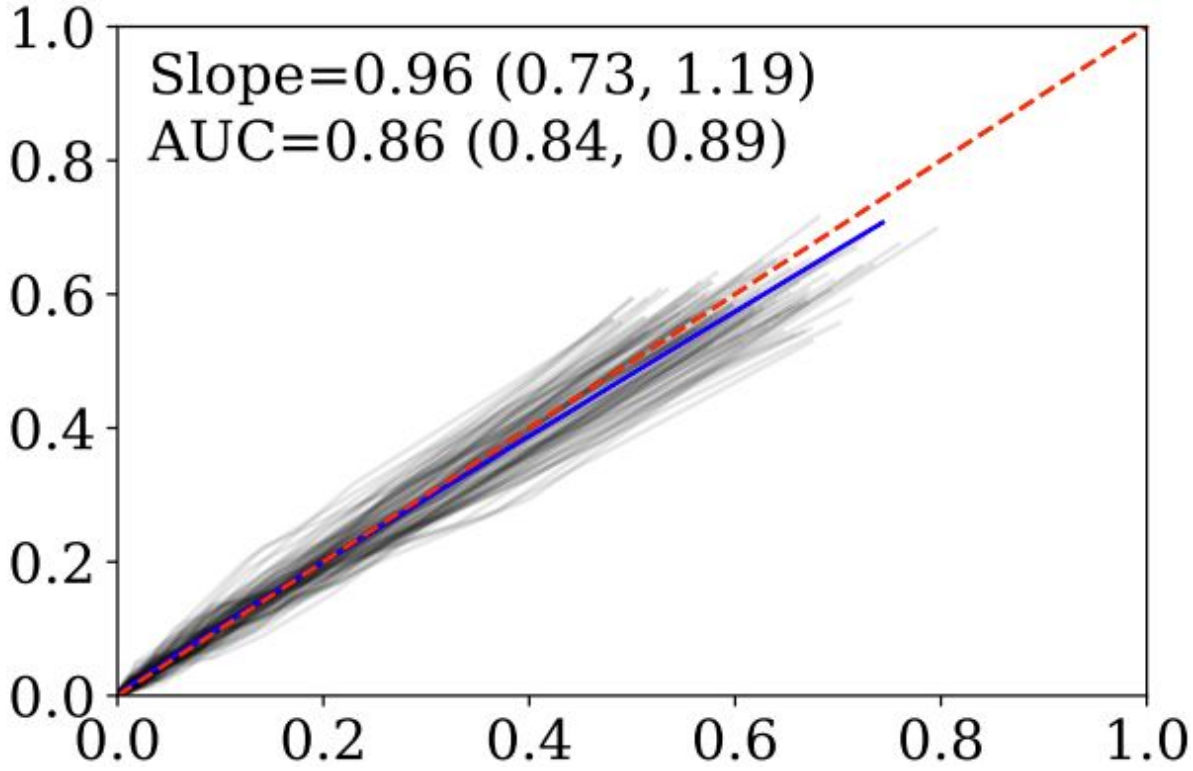
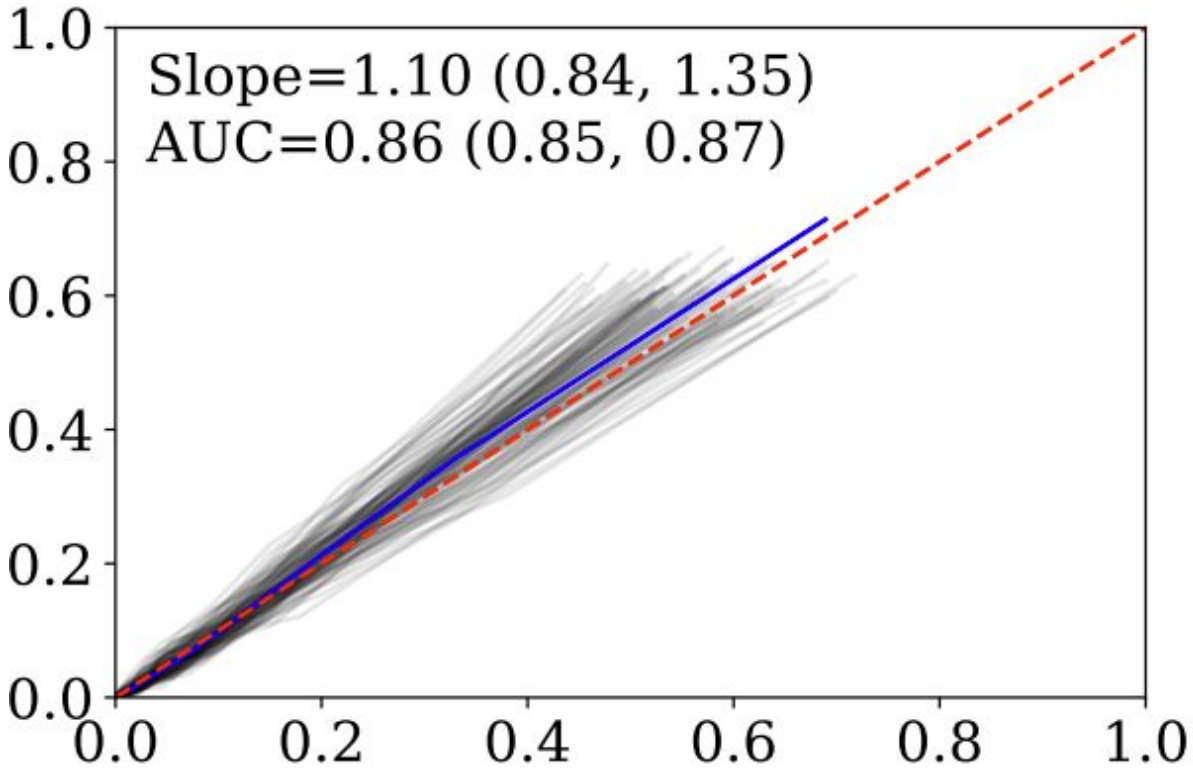


VIF=43 (EPV:6)

Results: Dropout



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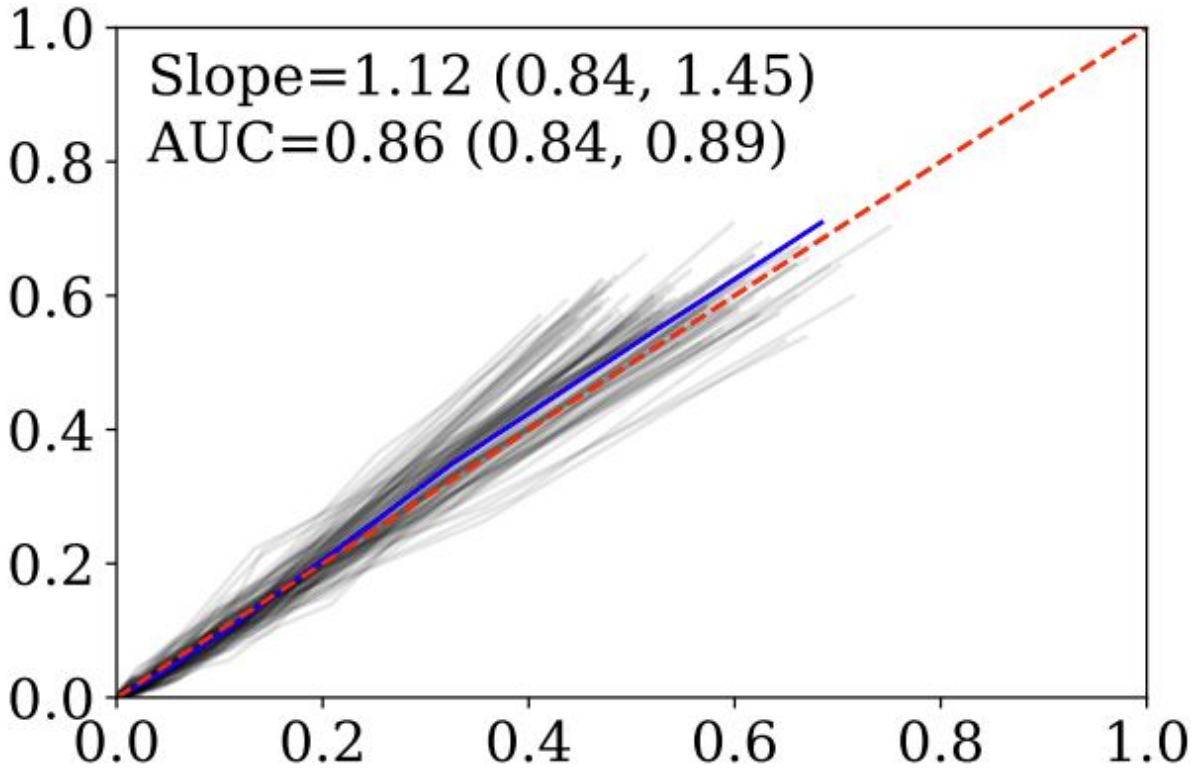
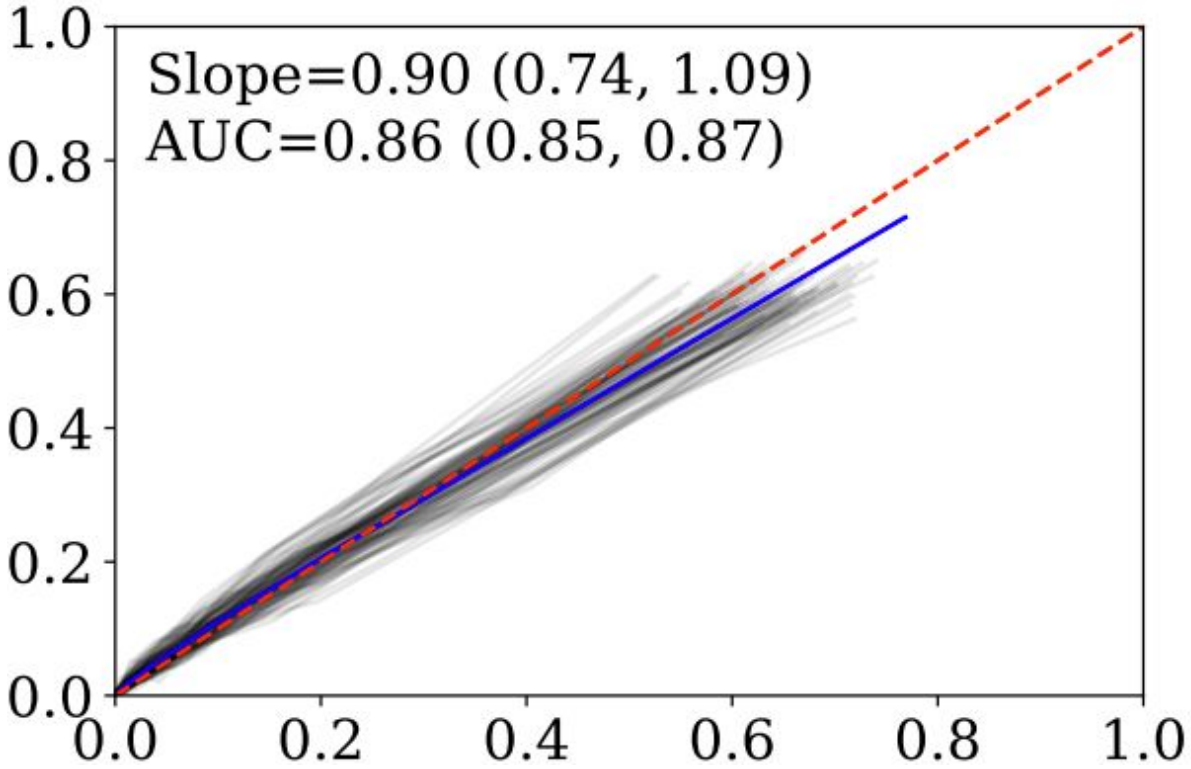
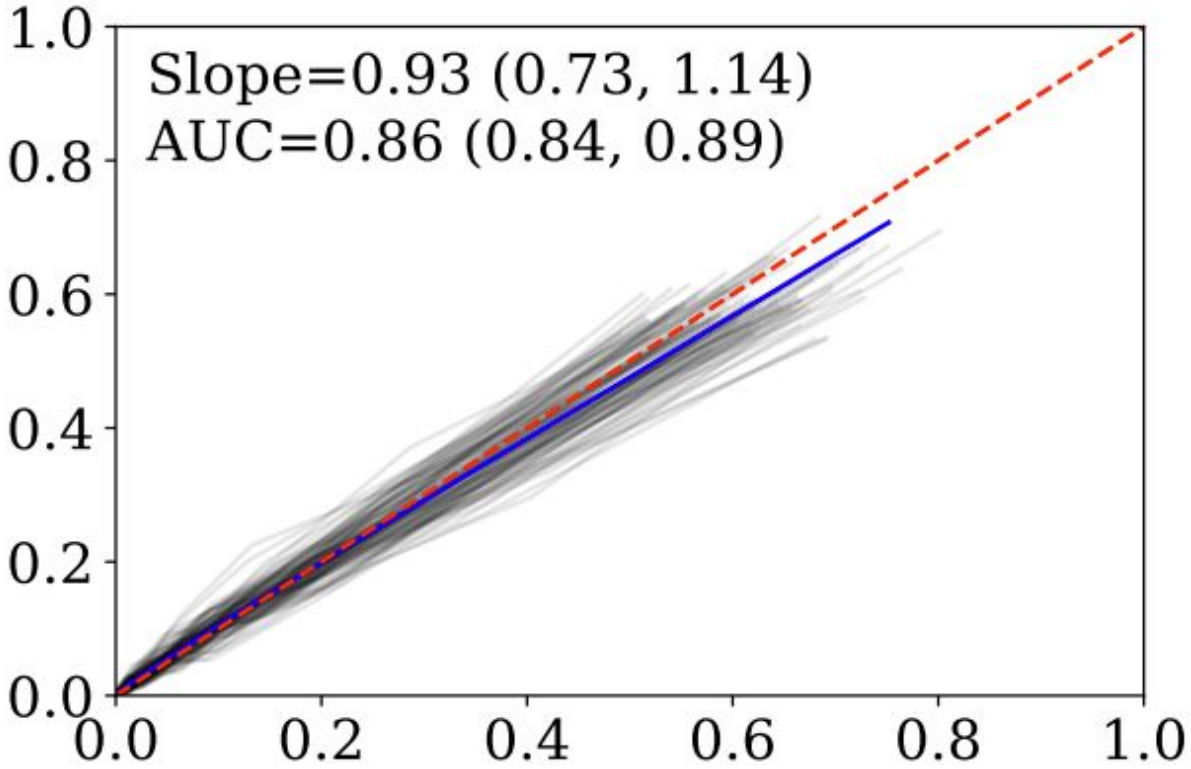


VIF=43 (EPV:6)

Results: LR_{NN}



VIF=5 (EPV:6)

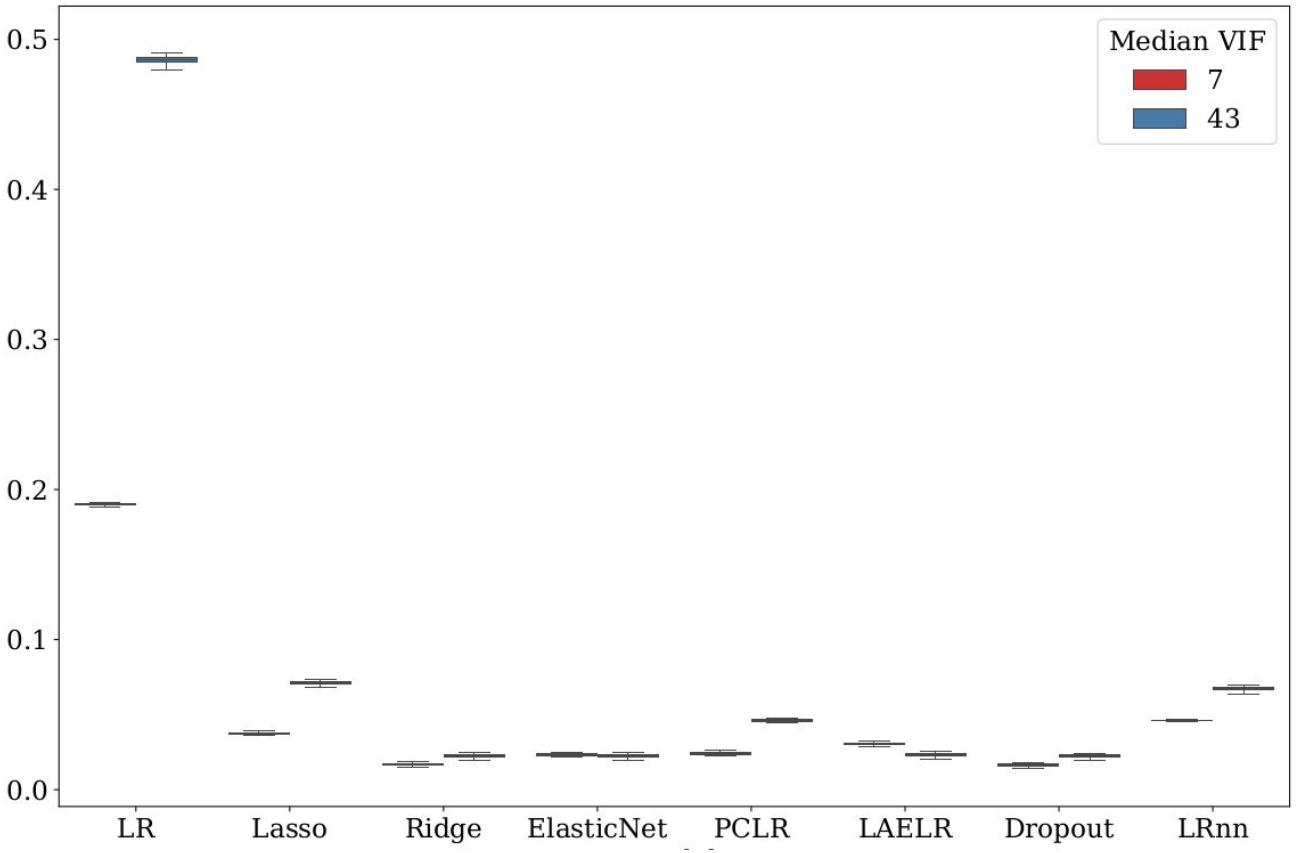


VIF=43 (EPV:6)

Confirmation

Collinearity did not impact predictive performance in the simulations.

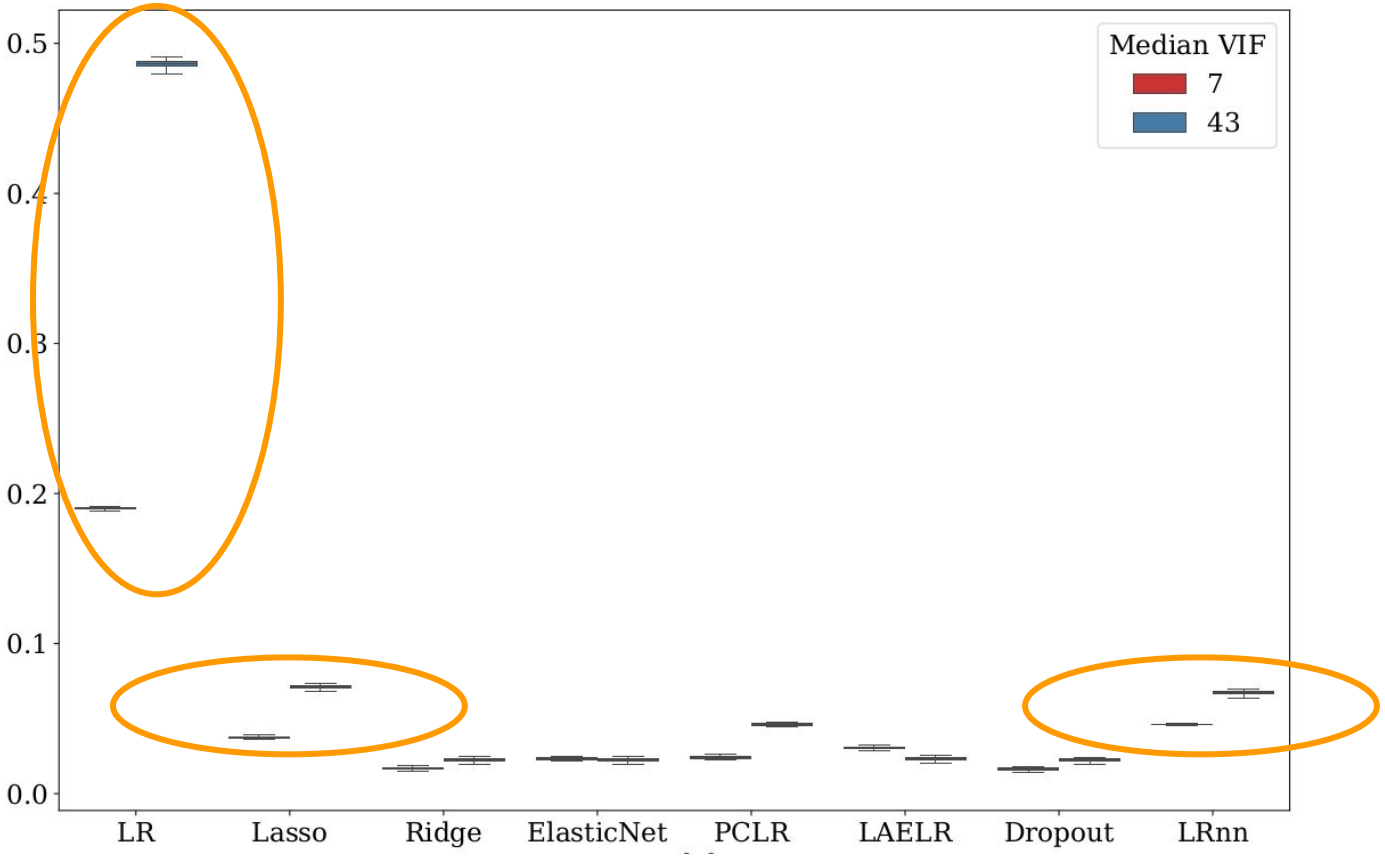
Coefficient estimation



MSE

How far are the estimated coefficients from the true coefficients?

Coefficient estimation



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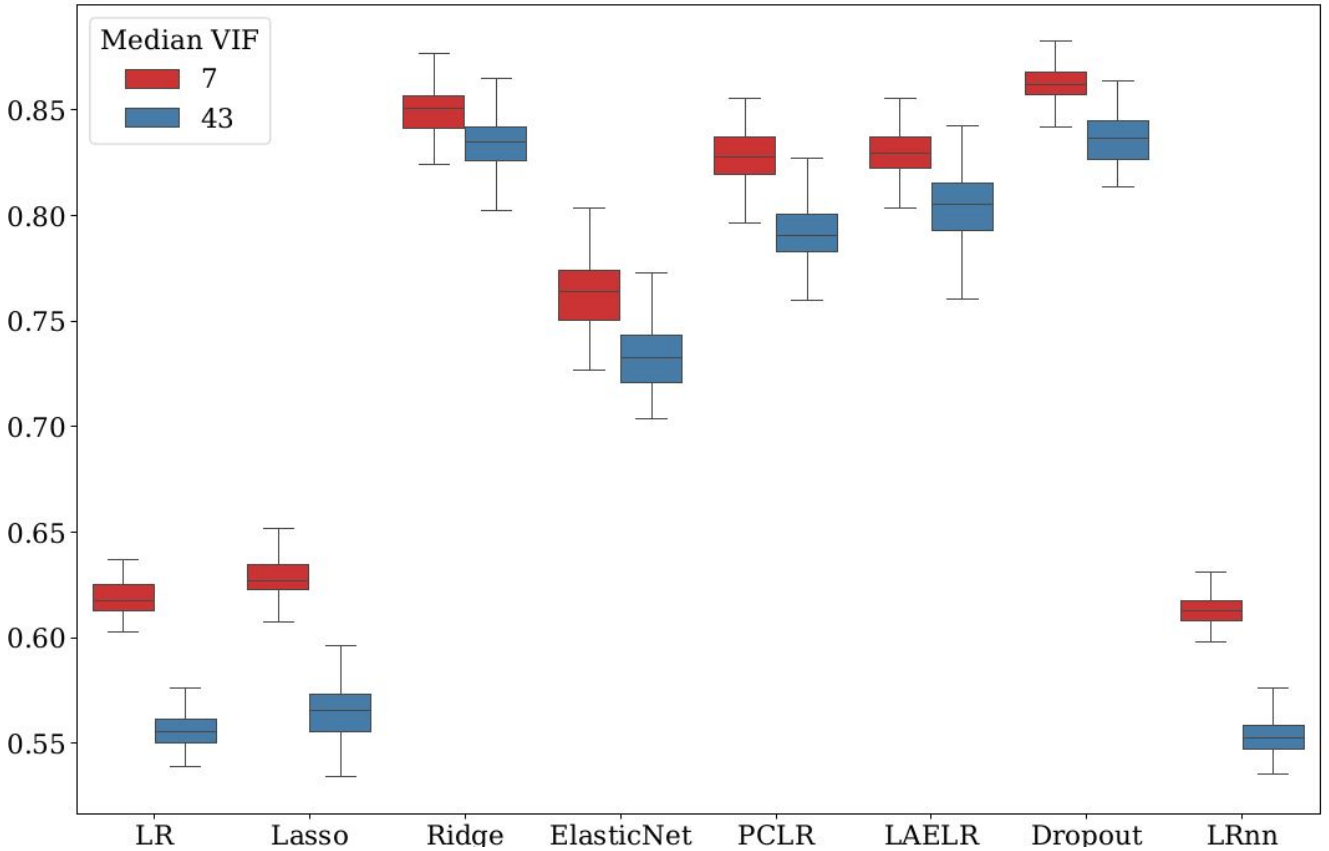
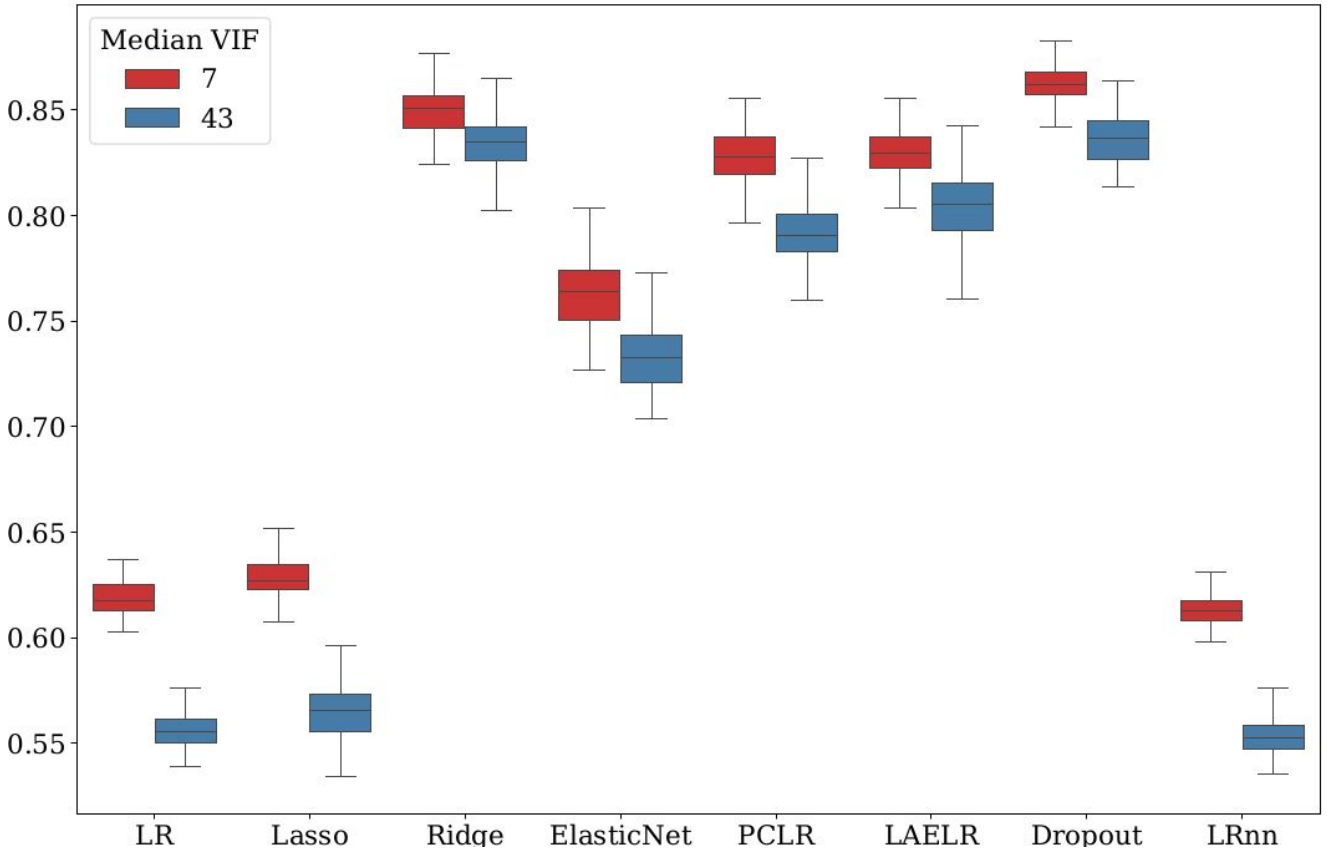


Expected Percentage of Similar Coefficients

What percentage of coefficients is expected to get the same sign when repeating the experiment?

Model A	Model B
0	0.45
0.33	0.22
-0.13	0.34

Coefficient estimation

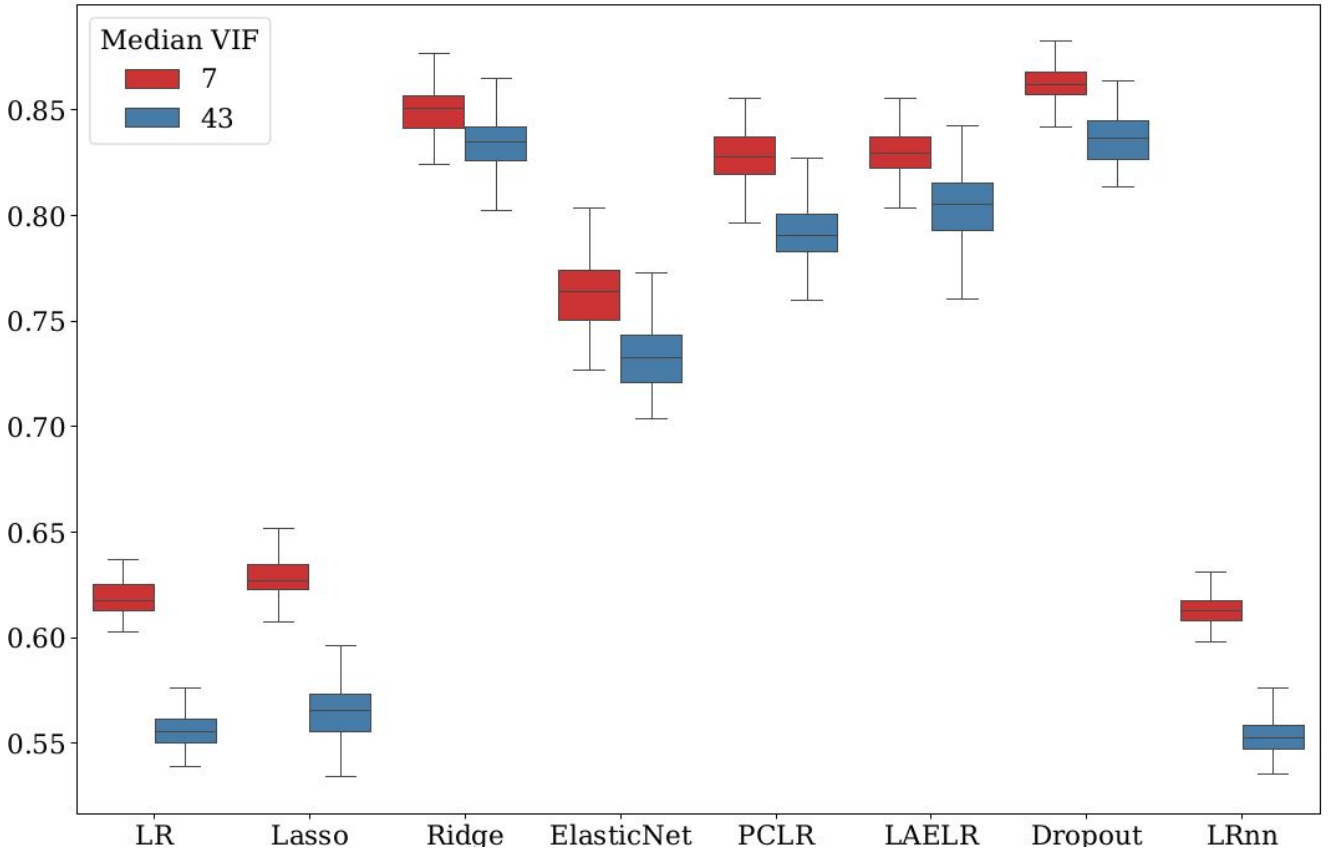


Expected Percentage of Similar Coefficients

What percentage of coefficients is expected to get the same sign when repeating the experiment?

Model A	Model B
0	+
+	+
-	+

Coefficient estimation



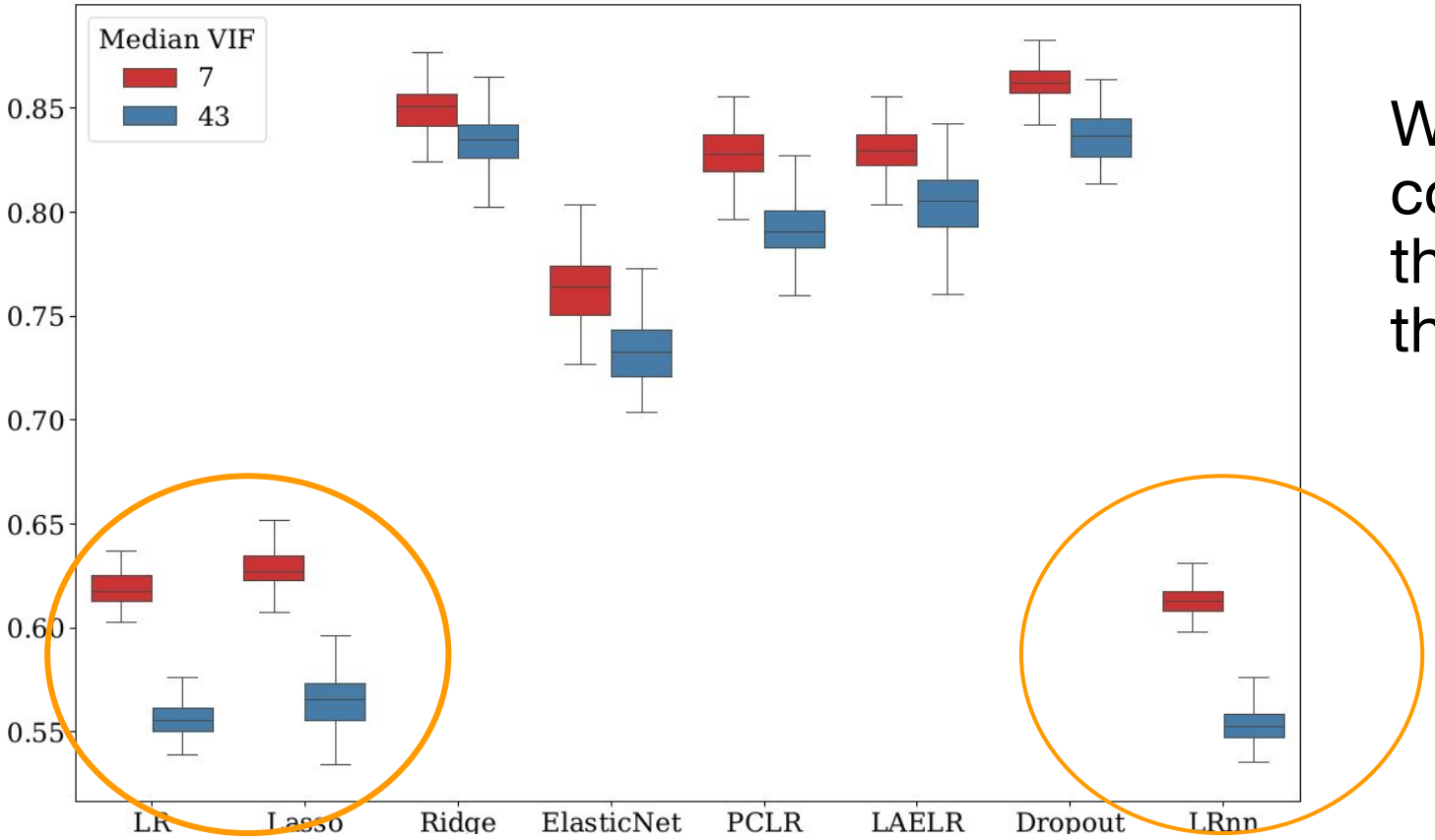
Expected Percentage of Similar Coefficients

What percentage of coefficients is expected to get the same sign when repeating the experiment?

Model A	Model B
0	+
+	+
-	+

$$\frac{1}{3}$$

Coefficient estimation



What percentage of coefficients is expected to get the same sign when repeating the experiment?

Expected Percentage of Similar Coefficients

Conclusions

(in presence of high collinearity)

<u>Predictive performance:</u>
Similar across methods.

<u>Coefficient estimation:</u>
For mostly LR, but also Lasso and LRnn

- Increase in MSE
- Less consistent selection of coefficients

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