Were the Scandinavian Crises Predictable? A Neural Network Approach.

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Contribution and Motivation

- The Purpose of this article is to compare the prediction ability of an artificial neural network (ANN) model to the usual Logit model in the context of Early Warning Systems (EWS) for banking crises
  - This has been done for currency and debt crises, but not for banking crises EWS

- Davis, Karim and Liadze (2011) have argued that early warning systems should be built for each region by themselves because of regional heterogenity of the variables signaling crises.
  - In this paper data is from three Nordic countries

Contribution and Motivation(2)

- Many Early Warning System (EWS) models have good in-sample results, but poor out-of-sample predictions (generalization ability)

- The usual models have assumed that the relationship between explanatory variables and the crises probability is linear, althought it is quite possibly in many cases nonlinear
  - E.g. the marginal increase of the crises probability might be larger for more severe declines of real GDP growth
  - Artificial Neural Network (ANN) can learn any nonlinear or linear continious function

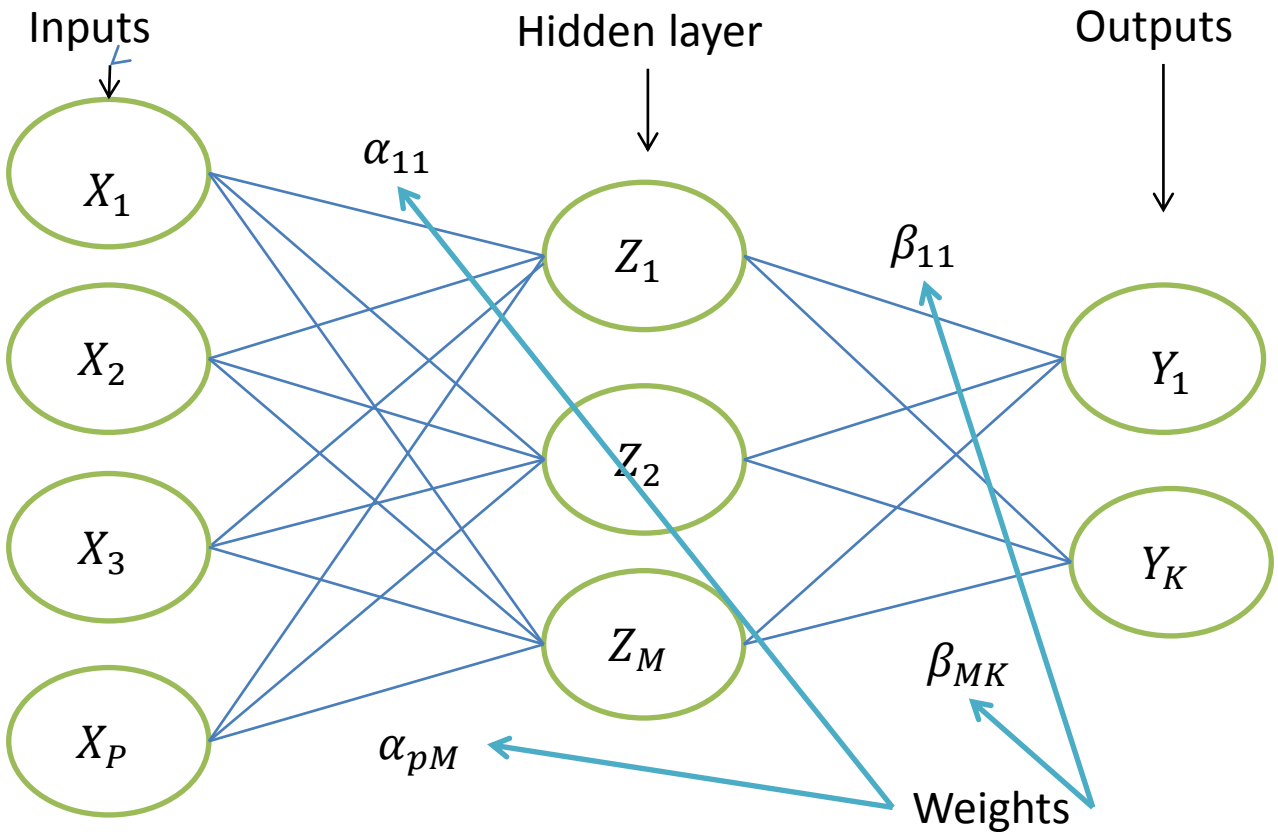
Quick Literature Review of EWS

- *Kaminsky, Lizondo and Reinhart (1998)* used nonparametric signal model (KLR) for currency crises
- *Berg and Pattillo (1999)* used multivariate logit model for currency crises
- After these papers the literature has spread to different types of financial crises and more complex/advanced models e.g. debt and banking crises, classification and regression tree analysis, ANN..
- Neural networks have been found to be superior in prediction compared with the logit (*Nag and Mitra (1999) ,Franck and Schmied (2003), Fioramanti (2008))*

Artificial Neural Networks

- A nonlinear nonparametric statistical method for both regression and classification problems that was originally inspired from neuroscience
- Used in various fields and applications including High performance aircraft autopilots, Check and other document readers, credit application evaluators, Breast cancer cell analysis, Speech recognition, facial recognition, mortgage screening, portfolio trading program to name a few
- Can approximate any continious function with any degree of accuracy if there are enough hidden neurons in the network
- Good alternative if there is little or no information on the relationship behind the explanatory variables and the dependent variable. Also if predicting is the primary interest and not interpretation.
- Often called a “blackbox” method, because it can be quite difficult or even impossible to interpret the weights/functions of the final network compared to the usual linear methods

Feed-forward multilayer perceptron (MLP) neural network with single hidden layer



$$Z_m = \sigma(\alpha_{0m} + \alpha_m X), m = 1, \ldots, M$$
$$T_k = \beta_{0k} + \beta_k Z, k = 1, \ldots . K$$
$$F_k(X) = g_k(T), k = 1, \ldots, K$$

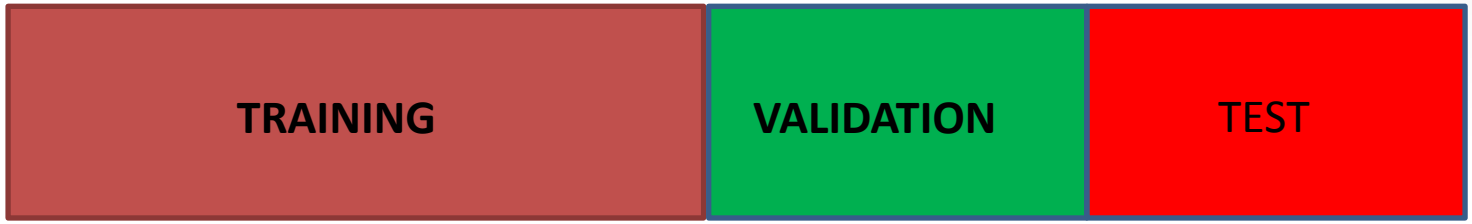
$$\sigma(v) = \frac{1}{(1 + e^{-v})}$$
$$g_k(T) = \frac{e^{T_k}}{\sum_{l=1}^{K} e^{T_l}}$$

Data and model selection process

- Monthly data from 1970 to 2003 from Finland, Sweden and Norway. Changed to quarterly data to fit house price data to the dataset.
  - Dozen explanatory variable candidates chosen from previous literature(e.g.inflation, credit growth). Mainly from Demirgüç-Kunt and Detragiache (1998) and Reinhart and Rogoff(2009).
  - Dependent binary variable for banking crises constructed using Kaminskys Financial crises chronology database.

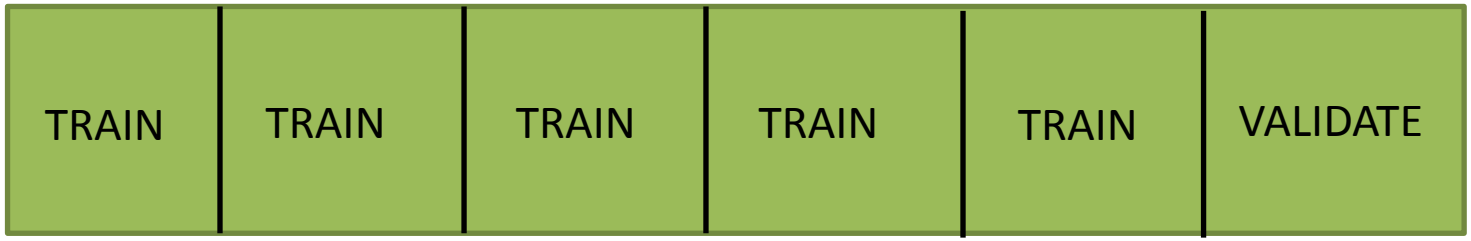
- The model selection process chosen from *Hastie, Tibshirani and Friedman(2009).*
  - Best model is the one that minimizes the expected prediction error of the model

1. DATA SPLITTING



2. K-FOLD CROSS VALDIATION (CV) FOR CHOOSING THE OPTIMAL MODEL FOR EACH METHOD USING THE FIRST TWO PARTS OF THE DATA

- LOGIT MODEL: BEST SUBSET OF PREDICTORS
- ANN: NUMBER OF HIDDEN NEURONS AND WEIGHT DECAY PARAMETER



3. CALCULATING THE FINAL PREDICTION ERROR FROM THE TEST DATA

THE CRITERIA IN THE VALDIATION (CV) AND THE TEST PHASE FOR THE BEST MODEL IS THE ONE THAT MAXIMIZES THE AREA UNDER THE ROC

Some preliminary results

10 indicator candidates:

Inflation, real interest rate of Germany and US, Stock price index, M2/Reserves, Credit/GDP level and growth, Deviation of the exchange rate from HP trend, Growth of exports and Terms of Trade.

Binary Dependent variable:

Banking crises period=1, Normal period=0.

276 obs in training/validation set and 67 obs in test set (ratio 0.8)

10-fold cross validation

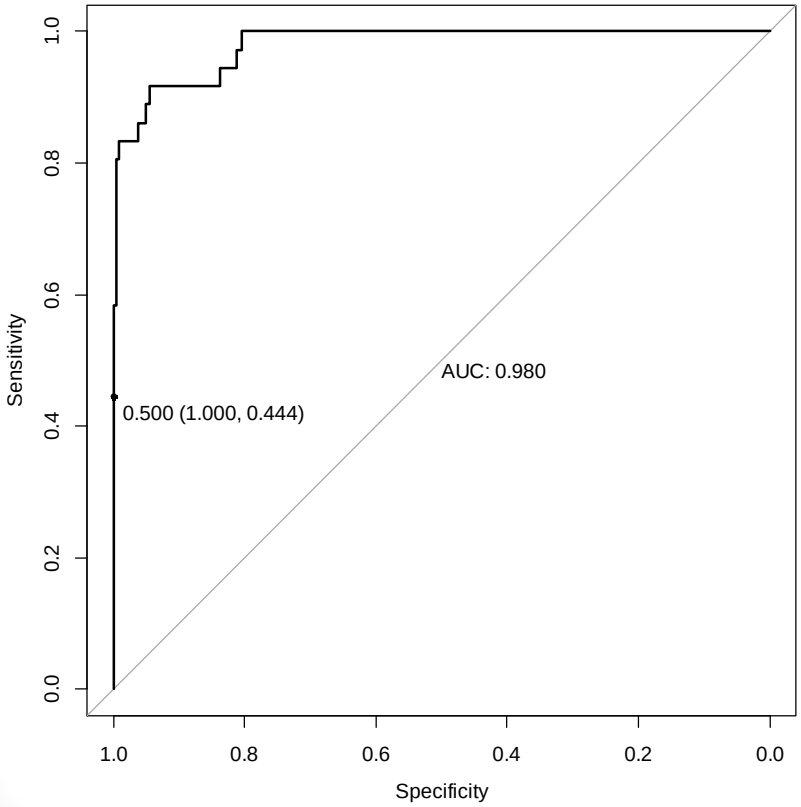
Variables are from Demirgüç-Kunt and Detragiache (1998) paper witch is the seminal paper for banking crises EWS.

They found that GDP growth, deviation of the currency, inflation, credit growth and M2/reserves were the most significant predictors of banking crises.

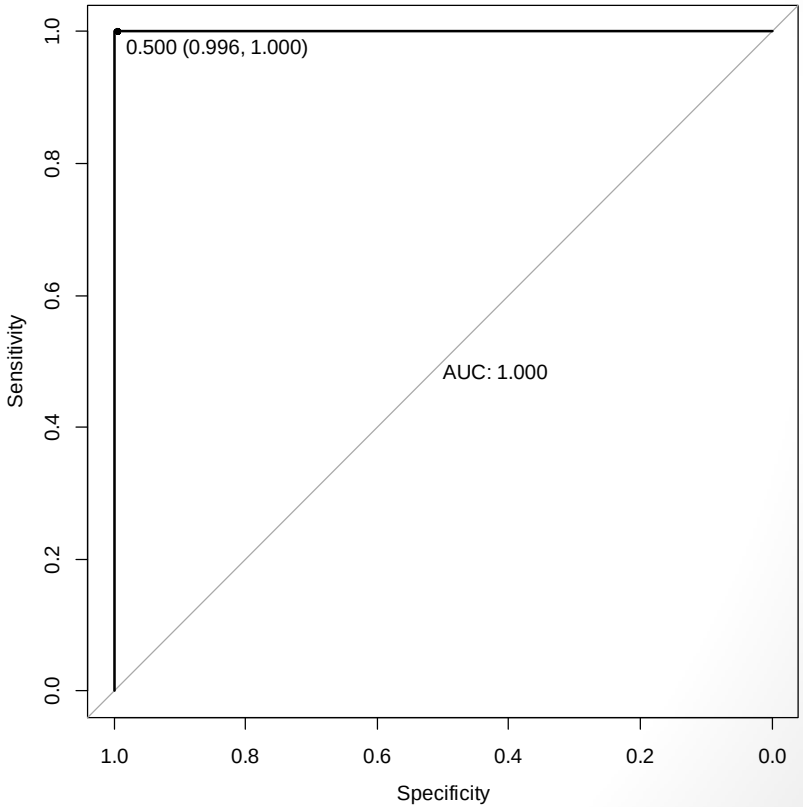
Due to data issues I had to leave real interest rates out, but I replaced it with real interest rate of Germany, which was found to increase before the Scandinavian crises

Results for the training set

LOGIT



NEURAL NETWORK

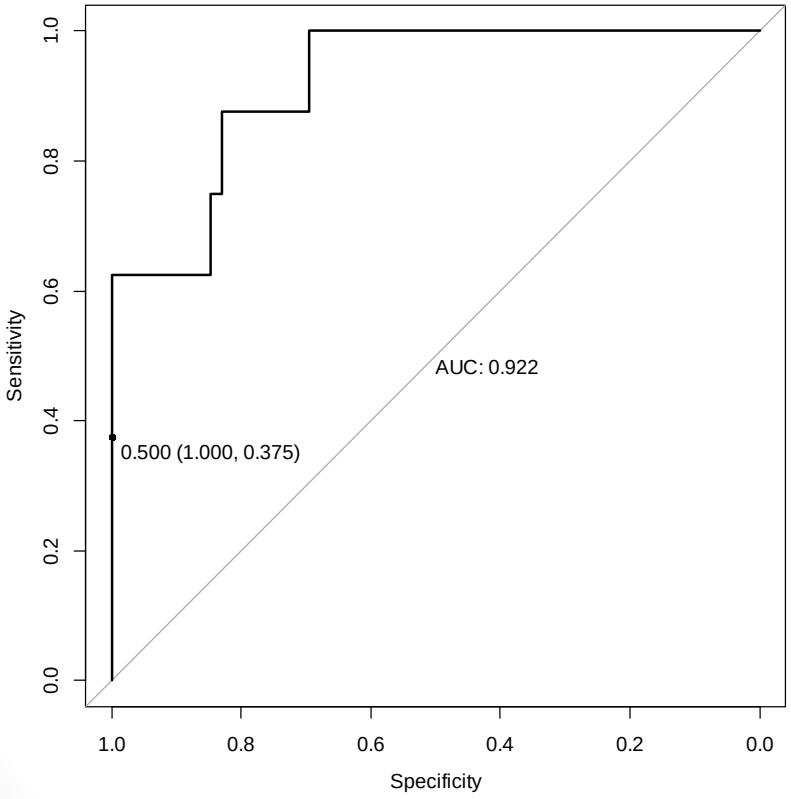


Resampling results (10 resamples) with the validation			
		Mean	Median
AUROC	ANN	1	0.9979
	LOGIT	0.9948	0.9701
Sensitivity	ANN	0.75	0.7750
	LOGIT	0.50	0.4333
Specificity	ANN	1	0.9875
	LOGIT	1	1

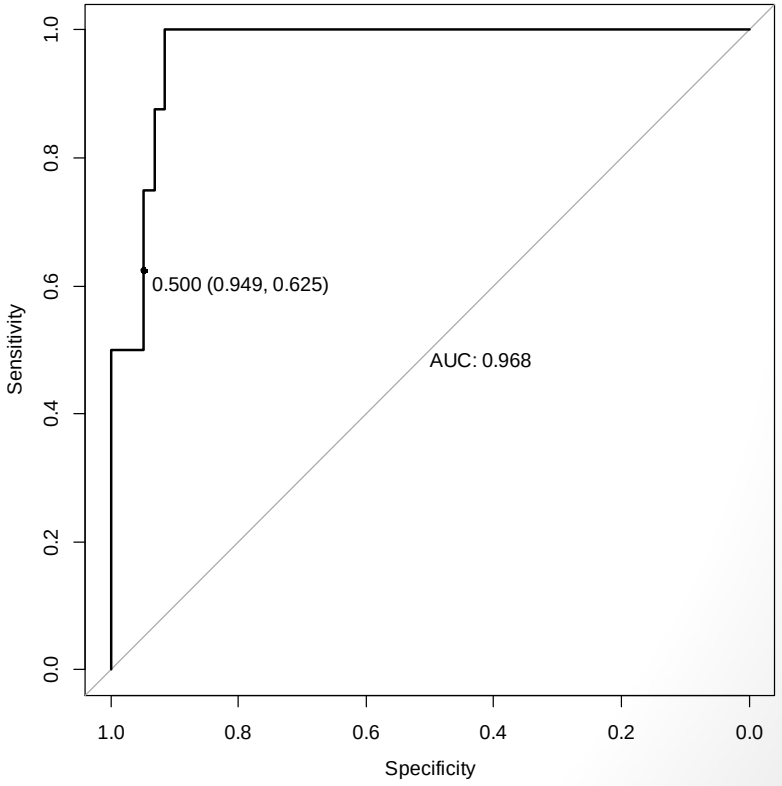
Results of the differences within each resample			
	Difference of the models ANN-Logit	P-value for H0: difference is 0	
AUROC	0.02778	0.0458	
Sensitivity	0.3417	0.01262	
Specificity	-0.0125	0.1934	

Test sample results

LOGIT



NEURAL NETWORK



Thank you for your patience!

Questions?