



THE UNIVERSITY OF  
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DEPARTMENT OF STATISTICS

# Master's Thesis Presentation

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“Extending to Binary Logistic Models”

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## Abstract

In many economic and financial applications, prediction is conducted in high-dimensional environments where individual covariates carry only weak and dispersed signals. While recent theory clarifies learnability under weak signals for linear regression, it remains unclear whether analogous patterns hold in discrete choice settings, where outcomes are binary and performance is evaluated by log-loss.

This thesis extends the benchmark-based weak-signal learning framework of Shen and Xiu (2024) to high-dimensional binary logistic models. Under weak-signal scaling, the null classifier is first-order optimal, making conventional risk ratios uninformative. To enable meaningful comparison, we introduce a scaled relative excess log-loss defined relative to the null classifier.

Our analysis reveals two regimes governing logistic excess risk. In a local regime, where both the true and fitted indices remain near zero, the logistic model admits a linear approximation and the excess log-loss becomes proportional to quadratic prediction error in a corresponding linear model. In this case, ridge can aggregate weak signals and achieve second-order improvements, while lasso does not generate systematic gains. In a non-local regime, where the fitted index moves away from zero, excess risk is dominated by a convex function of the index magnitude and decreases monotonically with stronger regularization.

Monte Carlo simulations are conducted to assess the finite-sample relevance of these theoretical insights across different signal strengths and sparsity structures. Overall, the results clarify how ridge and lasso behave under weak signals in high-dimensional logistic regression and provide a discrete-choice extension of weak-signal learning theory.

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