

## Neural Network-augmented Markov Transition Models for Credit Risk

### Abstract

Markov transition and survival models have both been used to model the dynamics of credit risk over time at account level. These are powerful tools to enable profit/loss estimation, roll-rate analysis, and as early warning systems. Over the past two decades there has been considerable work to enhance survival models to allow the inclusion of behavioural and macroeconomic data, and their integration with machine learning algorithms, to enhance the performance and usefulness of the models. However, there has been little development of the Markov transition model. In this study, we augment Markov models with neural network estimators which allows the inclusion of additional variables, and non-linear relationships, leading to a model similar to, but not the same as, a recurrent neural network.

Experiments with US mortgage data show that this proposed model is superior to the simple Markov transition model in terms of forecasting performance and calibration, whilst inheriting useful qualities of the Markov transition model. The augmented model opens the door to the inclusion of behavioural and macroeconomic data, which in turn, enables stress testing and Age-Period-Cohort analysis. It offers some advantages over survival models since it allows for the modelling of the process of default, and not just the default event, and naturally allows for the inclusion of competing risks such as early prepayment.

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