Final Project

Bayesian Time Series Regression Using MCMC To Predict The Financial Crisis of 2008

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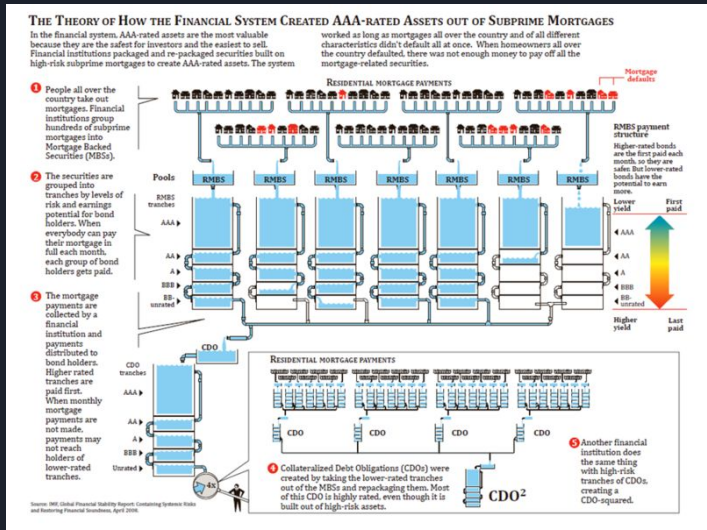
Main Objective

- To see whether Bayesian Methods could have been used to successfully predict the financial crisis of 2008 by looking at delinquency rates on loans
- Specific Bayesian Method Used: Bayesian Structural Time Series (BSTS)

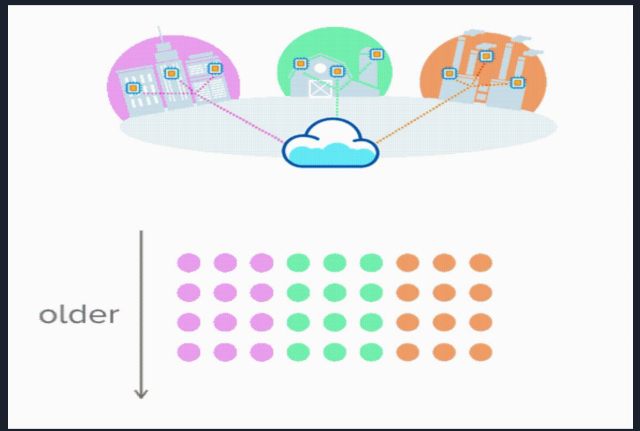
Great Recession

- When the housing bubble burst, the delinquency rates jumped dramatically.
- Delinquency rates especially skyrocketed for home mortgages.
- Main Reasons for the crash :
  - Very complex risky securities such as MBS(mortgage backed securities) were composed of very high risk mortgages.
  - Major financial institutions(the banks) were way overleveraged.
  - Federal Reserve policy wasn't ideal. Perhaps interest rates should have been raised during the housing boom to prevent overheating of the economy.



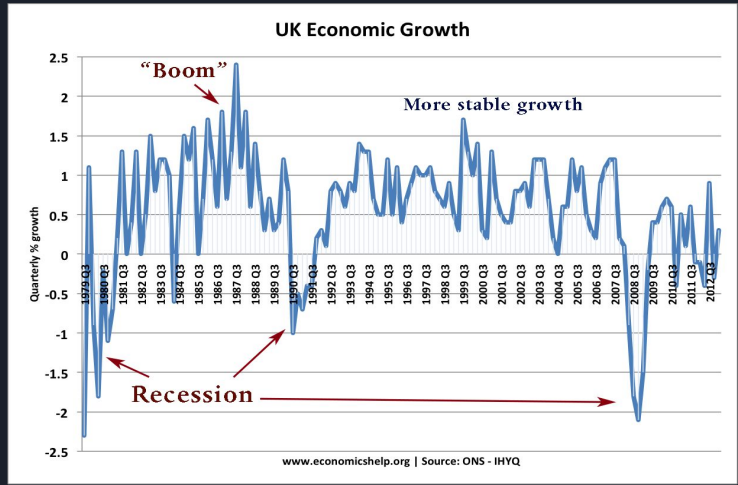
Bayesian Structural Time Series (BSTS)

- The BSTS model is designed to work with time series data, which is data that is recorded in time order as a new entry.
- Bayesian Structural Time Series is a technique used for time series forecasting, along with feature selection amongst its other uses.



Our Approach

- To see if predicting the future with the use of data without Bayesian Statistics would lead to extrapolation.
- With the use of BSTS, time series forecasting, and feature selection, we are able to take the fit of historical data (2000-2007) on the selected “Total Loans & Leases”, and predict the future outcome (2008) without the worry of extrapolation.

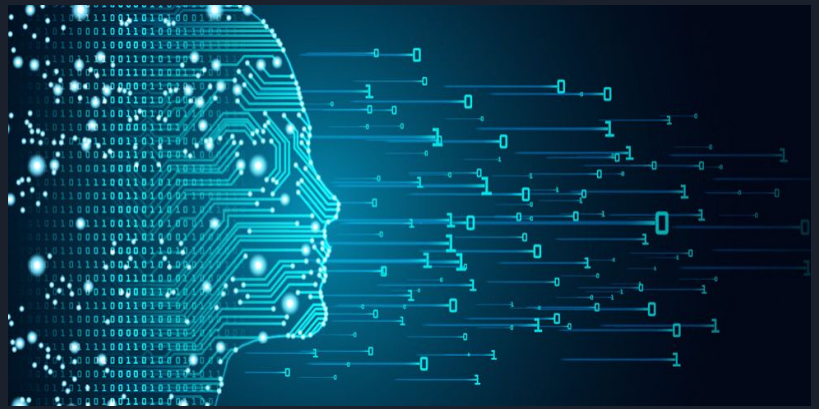


Process

1. Took quarterly delinquency rate data from 2000-2007 on all loans and fitted a Bayesian structural time series model for trend and seasonal components
2. Predicted data for the next 8 quarters(2 years) with a 95% credible interval
3. Graphed the actual data from the recession to compare the prediction accuracy of the forecast
4. Repeated steps 1-3 again but only used residential loan data this time around

Tools & DataSets

- Used BSTS package in R for modeling data
- Delinquency rates on loans and leases seemed to be a fitting dataset:
  - Federal Reserve
  - Broke years into quarters
  - Separated loans into residential, commercial and farmland loans
- Federal Reserve data



Bayesian Stats in-depth

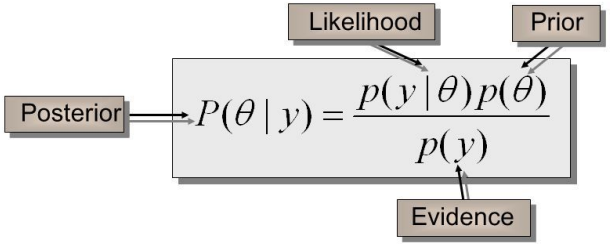
- The method can be split up into three stages
  - Kalman Filter - can add different state variables to the analysis including trend and seasonality
  - Spike and Slab- variable selection
  - Bayesian Model Averaging- Collect and predict
- In our cases we do the 1st and last stage as there aren't much predictors to select beside one(the time series data)
- The Bayesian Structural Time Series Method primarily depends on the Markov Chain Monte Carlo Method to sample from the posterior

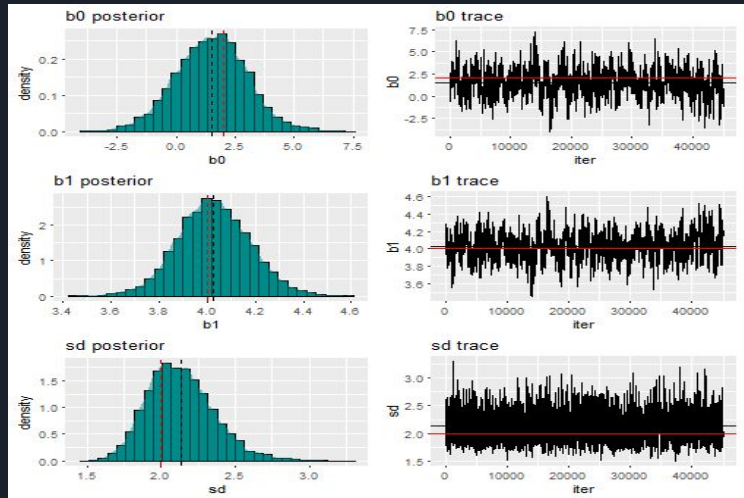
Bayes' Theorem

Given data y and parameters θ, the joint probability is:

$$p(y,\theta) = p(\theta \mid y)p(y) = p(y \mid \theta)p(\theta)$$

Eliminating $p(y,\theta)$ gives Bayes' rule:

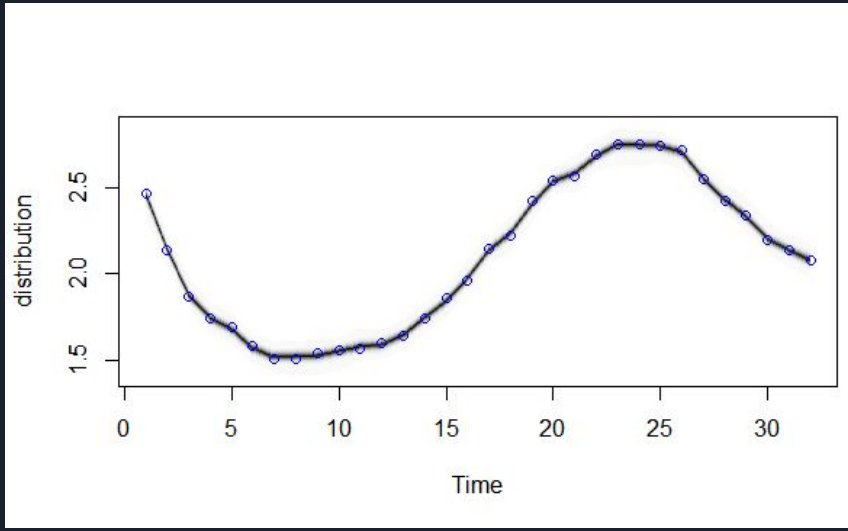




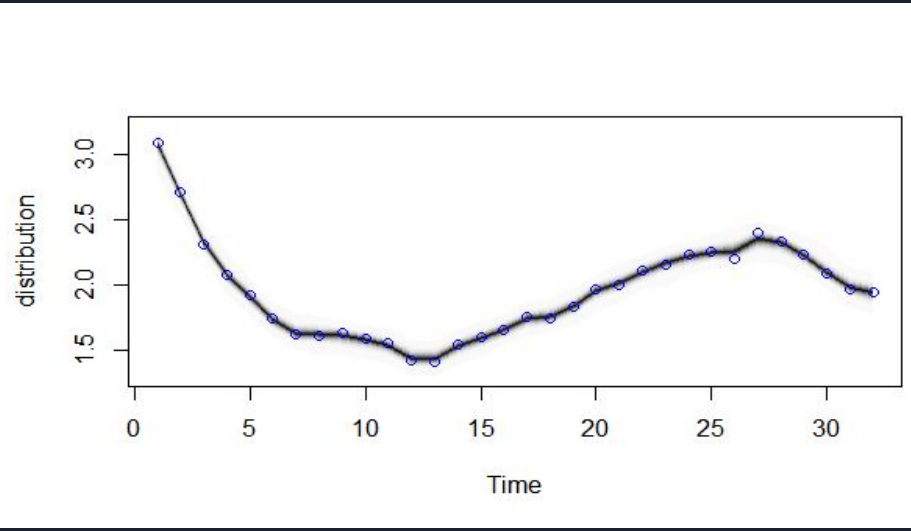
Fitted Bayesian Models before Recession

All Loans V. Residential

ALL LOANS



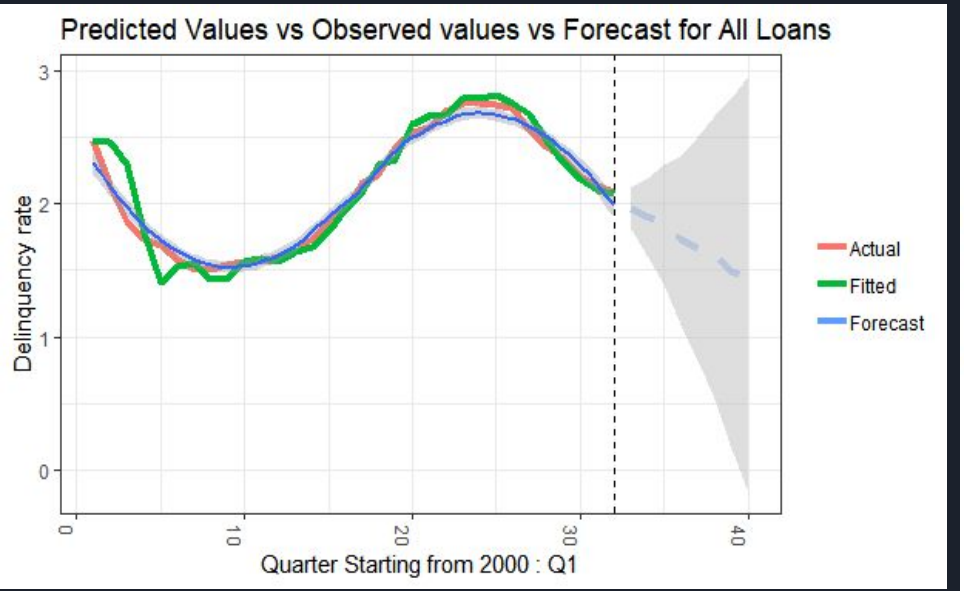
RESIDENTIAL



Predicted vs Observed vs Forecast

All Loans V. Residential

ALL LOANS



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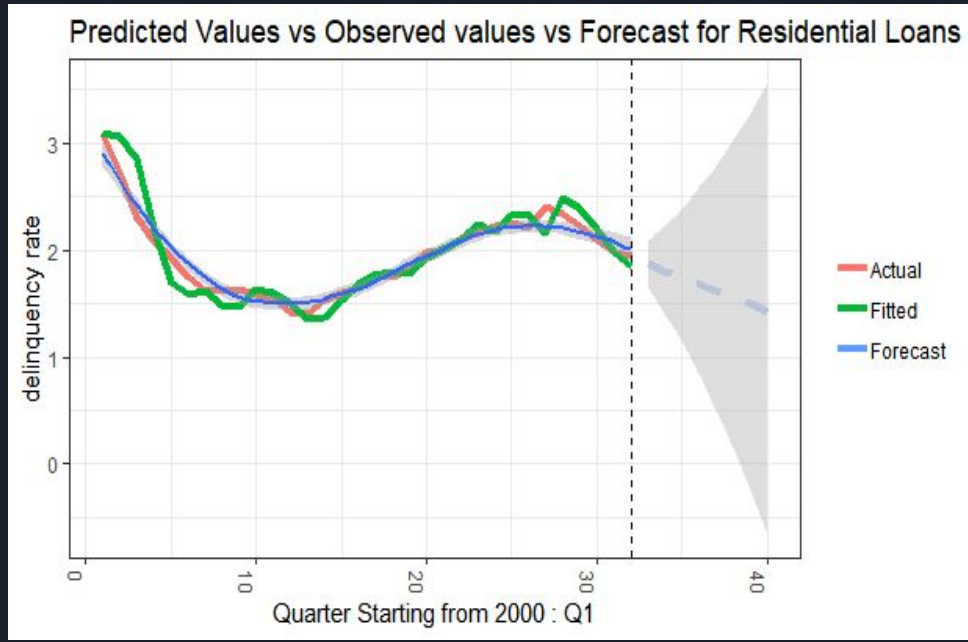

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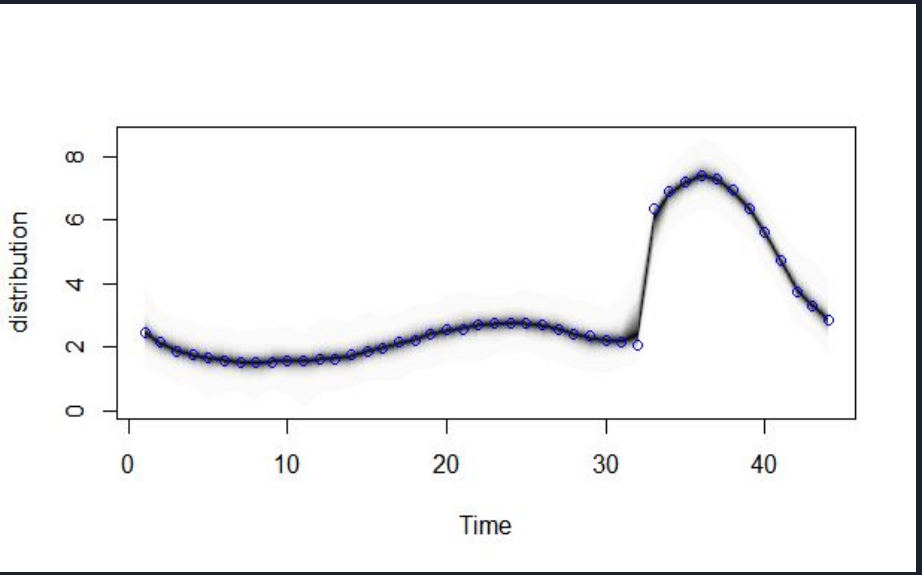
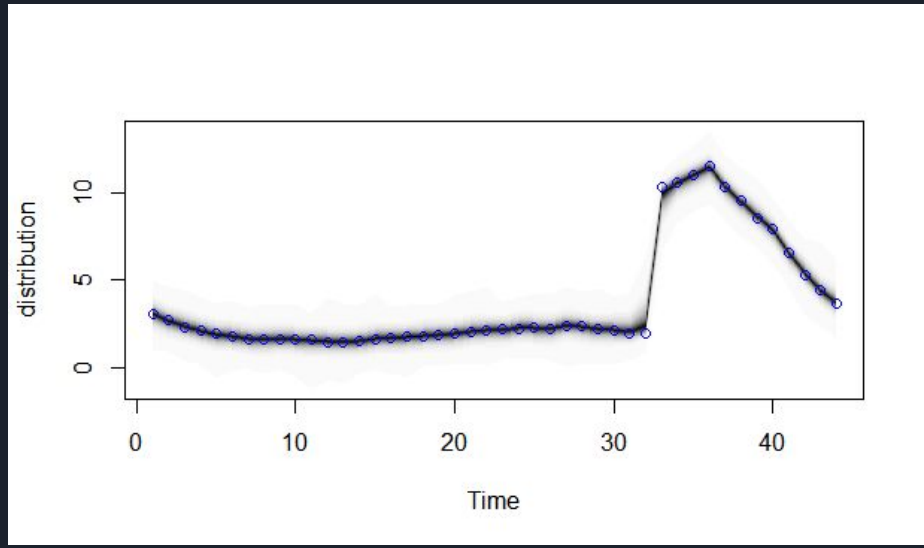


RESIDENTIAL LOANS



Analysis

- The relatively low standard deviation and high R-Squared value meaning the fitted model
  - Is good
  - Has predicted well
- Overall, it seemed as though the BSTS was a good fit
- However, the model predicts a decrease in loan delinquency rates when in reality the recession experienced a large spike in delinquency rates

All

$residual.sd
[1] 0.0234888

$prediction.sd
[1] 0.1193062

$rsquare
[1] 0.9971038

$relative.gof
[1] -0.004642704

Residential

$residual.sd
[1] 0.03538668

$prediction.sd
[1] 0.1555824

$rsquare
[1] 0.9913592

$relative.gof
[1] -0.2889068

It’s up to you!!!