Model Misspecification Risk in Stress Testing

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Given the unexpected severity of events, stress testing has gained greater attention.

Regulators looking towards regular bank stress tests to analyse systemic risk and ensure banks capital reserves are sufficient.

Greater focus on banks capital planning (Pillar 2 capital planning stress tests)

Why is model misspecification for stress testing important?
Regression Model

typical simple model

\texttt{lm(formula = Possession rate \sim Unemployment + Household Saving Rate + HPI)}

Coefficients:

| Estimate    | Std. Error | t value | Pr(>|t|) |
|-------------|------------|---------|----------|
| (Intercept) | 0.003468   | 0.010853| 0.320    | 0.7511   |
| Unemployment| 0.031720   | 0.012127| 2.616    | 0.0128 * |
| Household Saving Rate | 0.008637 | 0.005907| 1.462    | 0.1522   |
| HPI         | -0.002736  | 0.001340| -2.041   | 0.0485 * |

Residual standard error: 0.06942 on 37 degrees of freedom
Multiple R-squared: 0.4063, Adjusted R-squared: 0.3581
F-statistic: 8.439 on 3 and 37 DF, p-value: 0.0002119

Decent fit

No dependence on Mortgage Rate or GDP?
Regression Model

introduce GDP

lm(formula = Possession rate ~ Unemployment + Household Saving Rate + GDP,)

Coefficients:

|                | Estimate | Std. Error | t value | Pr(>|t|) |
|----------------|----------|------------|---------|----------|
| (Intercept)    | 0.003473 | 0.011064   | 0.314   | 0.75538  |
| Unemployment   | 0.038493 | 0.011353   | 3.391   | 0.00167 **|
| Household Saving Rate | 0.005930 | 0.006215 | 0.954 | 0.34617 |
| GDP            | -0.007768 | 0.004808  | -1.616  | 0.11464  |

Residual standard error: 0.07077 on 37 degrees of freedom
Multiple R-squared: 0.3830, Adjusted R-squared: 0.3329
F-statistic: 7.655 on 3 and 37 DF, p-value: 0.0004208

- Very little difference in performance?
- Is GDP a better model to include or not?
- What is the model miss-specification error?
**Regression Model**

*introduce Lags*

|                        | Estimate | Std. Error | t value | Pr(>|t|) |
|------------------------|----------|------------|---------|----------|
| (Intercept)            | 0.010844 | 0.528      | 0.6013  |          |
| Unemployment           | 0.033900 | 0.014294   | 2.372   | 0.0241 * |
| GDP                    | -0.008622| 0.005027   | -1.715  | 0.0963 . |
| RPI                    | -0.007480| 0.005140   | -1.455  | 0.1557   |
| Average Earnings       | 0.009405 | 0.005560   | 1.692   | 0.1007   |
| Lagged RPI             | -0.008877| 0.005365   | -1.655  | 0.1081   |
| Lagged Average Earnings| 0.009246 | 0.005444   | 1.699   | 0.0994 . |
| Lagged Household Saving Rate | 0.010683 | 0.005984 | 1.785 | 0.0840 . |
| Lagged Mortgage Rate   | -0.019369| 0.007832   | -2.473  | 0.0191 * |

Multiple R-squared: 0.5219, Adjusted R-squared: 0.3986

F-statistic: 4.231 on 8 and 31 DF, p-value: 0.001615

- Even “better” model using lag of 1.
- But many of the parameter signs are reversed
- Only considered lag of 1 year (what about 2, 3 etc.)
What have we learned?

- Building time series models for robust stress testing is difficult
  - Models are poorly specified – that is it is possible to choose two similar performing and plausible models with quite different parameters
  - Better models statistically often don’t make sense in practice
- These are manifestations of model misspecification risk.
- Misspecified models lose some or all of the desirable properties of our estimators: unbiasedness, efficiency and consistency

- The rest of this paper investigates the effect of minimising model misspecification risk on future scenario forecasts
Model Misspecification

time series data

- Raw time series data 1970-2012
- Differenced time series used for modelling
- Non linear relationships not considered
Model Misspecification approach

Macroeconomic model

- Least Absolute Shrinkage and Selection Operation ("LASSO") regression
  - Shrinkage and Selection process to produce models of varying complexity
- Bootstrapped to simulate uncertainty in model parameters

Scenario Simulation

- Monte Carlo using Cholesky Decomposition
  - Simulate system with multiple correlated parameters
- Monte Carlo to simulate uncertainty in future scenarios
Mean-Squared Error (MSE) as measure to assess models

Optimum model complexity with lowest MSE:
- GDP, Unemployment, Lagged Unemployment, HPI

Bias-variance trade off
- \( \text{MSE} = \text{bias}^2 + \text{variance} + \text{noise} \)
Model Misspecification

scenario simulation

- Higher model complexity / Lower bias in estimator
  - Higher variance
- Simple model – low variation, low forecast estimates => understate forecast
- Complex model – high variation, high forecast estimates => overstate forecast

MSE : 0.007311  
MSE : 0.007114  
MSE : 0.007311
Conclusion

- Minimising model misspecification error (in terms of bias) may potentially overstate credit-losses, however:
  - Minimising MSE produces a simple model based on GDP, Unemployment and HPI – this will not capture variation
  - Introduce model misspecification error by selecting parameters that are not well defined within future stress scenarios
  - And given the recent crisis, overstating credit-losses may not be such a bad thing!
  - Balance between model robustness and model misspecification error