# **Forecasting Methods**

## **Case study 2**

**Lalitha Chockalingam, Uma**

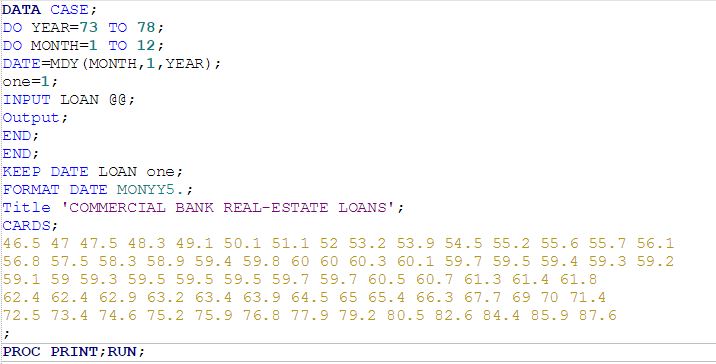
**Chaurasiya, Abhishek**

**Rocabado, Oscar**

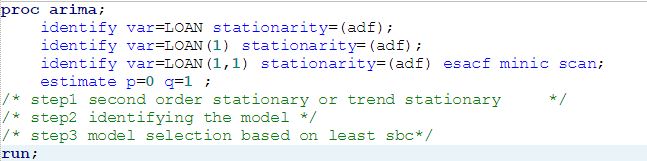
**Case study**

The series analyzed here is the monthly volume of commercial bank real-estate loans, in billions of dollars, from January 1973 to October 1978, a total of 70 observations. The data are derived from reports to the Federal Reserve System from large commercial banks.

Here is the data with 70 observations from January 1973 through October 1978:



Code:



**Step 1: Stationarity Check – ADF-** Augmented Dickey Fuller test is used to check whether a time series is stationary or not. It checks for stationarity in both mean and in the trend, as both as necessary for a series to be stationary.

Results:

LOAN variable is non-stationary.

LOAN (1) - First order difference is also non-stationary.

LOAN (1, 1) - The second order differencing results in a stationary time series, with Autocorrelation check results reflecting white noise.

| **Name of Variable = LOAN** | |
| --- | --- |
| **Mean of Working Series** | 62.7 |
| **Standard Deviation** | 9.427952 |
| **Number of Observations** | 70 |

| **Autocorrelation Check for White Noise** | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **To Lag** | **Chi-Square** | **DF** | **Pr > ChiSq** | **Autocorrelations** | | | | | |
| **6** | 262.43 | 6 | <.0001 | 0.926 | 0.853 | 0.782 | 0.715 | 0.653 | 0.595 |
| **12** | 352.56 | 12 | <.0001 | 0.540 | 0.489 | 0.441 | 0.394 | 0.347 | 0.303 |

| **Augmented Dickey-Fuller Unit Root Tests** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Type** | **Lags** | **Rho** | **Pr < Rho** | **Tau** | **Pr < Tau** | **F** | **Pr > F** |
| **Zero Mean** | 0 | 0.6891 | 0.8479 | 10.68 | 0.9999 |  |  |
|  | 1 | 0.7757 | 0.8667 | 2.13 | 0.9916 |  |  |
|  | 2 | 0.8937 | 0.8898 | 1.48 | 0.9647 |  |  |
| **Single Mean** | 0 | 2.1198 | 0.9978 | 5.06 | 0.9999 | 72.19 | 0.0010 |
|  | 1 | 2.4930 | 0.9988 | 1.65 | 0.9995 | 3.08 | 0.2947 |
|  | 2 | 2.9240 | 0.9994 | 1.26 | 0.9983 | 1.60 | 0.6678 |
| **Trend** | 0 | 4.1693 | 0.9999 | 3.63 | 0.9999 | 15.14 | 0.0010 |
|  | 1 | 1.3936 | 0.9992 | 0.33 | 0.9984 | 1.39 | 0.8972 |
|  | 2 | -3.5464 | 0.9069 | -0.42 | 0.9848 | 1.26 | 0.9233 |



| **Name of Variable = LOAN** | |
| --- | --- |
| **Period(s) of Differencing** | 1 |
| **Mean of Working Series** | 0.595652 |
| **Standard Deviation** | 0.525973 |
| **Number of Observations** | 69 |
| **Observation(s) eliminated by differencing** | 1 |

| **Autocorrelation Check for White Noise** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **To Lag** | **Chi-Square** | **DF** | **Pr > ChiSq** | **Autocorrelations** | | | | | |
| **6** | 159.87 | 6 | <.0001 | 0.801 | 0.732 | 0.649 | 0.501 | 0.435 | 0.353 |
| **12** | 212.77 | 12 | <.0001 | 0.337 | 0.307 | 0.320 | 0.368 | 0.332 | 0.294 |

| **Augmented Dickey-Fuller Unit Root Tests** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Type** | **Lags** | **Rho** | **Pr < Rho** | **Tau** | **Pr < Tau** | **F** | **Pr > F** |
| **Zero Mean** | 0 | -3.1259 | 0.2215 | -0.96 | 0.2987 |  |  |
|  | 1 | -0.4866 | 0.5701 | -0.21 | 0.6086 |  |  |
|  | 2 | 0.0691 | 0.6955 | 0.03 | 0.6903 |  |  |
| **Single Mean** | 0 | -9.7719 | 0.1280 | -2.02 | 0.2796 | 2.15 | 0.5295 |
|  | 1 | -4.0606 | 0.5217 | -1.09 | 0.7149 | 0.81 | 0.8649 |
|  | 2 | -2.4250 | 0.7211 | -0.71 | 0.8355 | 0.46 | 0.9591 |
| **Trend** | 0 | -13.1094 | 0.2264 | -2.52 | 0.3168 | 3.44 | 0.4966 |
|  | 1 | -6.5596 | 0.6829 | -1.62 | 0.7745 | 1.79 | 0.8191 |
|  | 2 | -4.9427 | 0.8156 | -1.36 | 0.8625 | 1.92 | 0.7952 |



| **Name of Variable = LOAN** | |
| --- | --- |
| **Period(s) of Differencing** | 1,1 |
| **Mean of Working Series** | 0.017647 |
| **Standard Deviation** | 0.305797 |
| **Number of Observations** | 68 |
| **Observation(s) eliminated by differencing** | 2 |

| **Autocorrelation Check for White Noise** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **To Lag** | **Chi-Square** | **DF** | **Pr > ChiSq** | **Autocorrelations** | | | | | |
| **6** | 13.75 | 6 | 0.0325 | -0.361 | -0.006 | 0.139 | -0.106 | 0.048 | -0.163 |
| **12** | 18.15 | 12 | 0.1112 | 0.078 | -0.101 | -0.090 | 0.148 | 0.055 | -0.071 |

| **Augmented Dickey-Fuller Unit Root Tests** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Type** | **Lags** | **Rho** | **Pr < Rho** | **Tau** | **Pr < Tau** | **F** | **Pr > F** |
| **Zero Mean** | 0 | -91.0946 | <.0001 | -11.79 | <.0001 |  |  |
|  | 1 | -121.181 | 0.0001 | -7.71 | <.0001 |  |  |
|  | 2 | -81.3701 | <.0001 | -4.88 | <.0001 |  |  |
| **Single Mean** | 0 | -91.3412 | 0.0006 | -11.76 | 0.0001 | 69.17 | 0.0010 |
|  | 1 | -123.199 | 0.0001 | -7.70 | 0.0001 | 29.66 | 0.0010 |
|  | 2 | -84.4053 | 0.0006 | -4.86 | 0.0002 | 11.86 | 0.0010 |
| **Trend** | 0 | -91.8831 | 0.0002 | -11.80 | <.0001 | 69.57 | 0.0010 |
|  | 1 | -130.308 | 0.0001 | -7.88 | <.0001 | 31.07 | 0.0010 |
|  | 2 | -102.283 | 0.0001 | -5.08 | 0.0005 | 12.93 | 0.0010 |



**Step 2: Identifying the model**

| **Squared Canonical Correlation Estimates** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Lags** | **MA 0** | **MA 1** | **MA 2** | **MA 3** | **MA 4** | **MA 5** |
| **AR 0** | 0.1313 | <.0001 | 0.0204 | 0.0133 | 0.0027 | 0.0314 |
| **AR 1** | 0.0239 | 0.0218 | 0.0187 | 0.0024 | 0.0132 | 0.0319 |
| **AR 2** | 0.0098 | 0.0008 | <.0001 | 0.0169 | 0.0062 | 0.0038 |
| **AR 3** | 0.0006 | <.0001 | 0.0024 | 0.0164 | 0.0001 | 0.0101 |
| **AR 4** | <.0001 | 0.0005 | 0.0133 | 0.0106 | 0.0148 | 0.0008 |
| **AR 5** | 0.0461 | 0.0397 | 0.0229 | 0.0215 | 0.0121 | 0.0075 |

| **SCAN Chi-Square[1] Probability Values** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Lags** | **MA 0** | **MA 1** | **MA 2** | **MA 3** | **MA 4** | **MA 5** |
| **AR 0** | 0.0020 | 0.9644 | 0.3003 | 0.4148 | 0.7189 | 0.2185 |
| **AR 1** | 0.2033 | 0.2564 | 0.2859 | 0.7125 | 0.4074 | 0.2632 |
| **AR 2** | 0.4206 | 0.8403 | 0.9497 | 0.3299 | 0.6209 | 0.7082 |
| **AR 3** | 0.8377 | 0.9868 | 0.7351 | 0.3765 | 0.9510 | 0.5333 |
| **AR 4** | 0.9470 | 0.8650 | 0.3715 | 0.5186 | 0.4458 | 0.8720 |
| **AR 5** | 0.0846 | 0.1953 | 0.3035 | 0.3673 | 0.5361 | 0.6015 |

| **Extended Sample Autocorrelation Function** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Lags** | **MA 0** | **MA 1** | **MA 2** | **MA 3** | **MA 4** | **MA 5** |
| **AR 0** | -0.3614 | -0.0060 | 0.1394 | -0.1064 | 0.0477 | -0.1628 |
| **AR 1** | -0.3700 | -0.0038 | 0.1242 | -0.0663 | -0.0259 | -0.1625 |
| **AR 2** | 0.4573 | 0.0783 | 0.0133 | -0.0451 | -0.0399 | -0.0684 |
| **AR 3** | 0.2525 | -0.0157 | 0.0304 | -0.1619 | 0.0069 | -0.0553 |
| **AR 4** | 0.2874 | 0.0052 | 0.0947 | -0.1789 | 0.0398 | -0.0858 |
| **AR 5** | 0.0339 | -0.0636 | 0.3565 | -0.3433 | -0.1484 | -0.0577 |

| **ESACF Probability Values** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Lags** | **MA 0** | **MA 1** | **MA 2** | **MA 3** | **MA 4** | **MA 5** |
| **AR 0** | 0.0029 | 0.9648 | 0.3062 | 0.4416 | 0.7325 | 0.2438 |
| **AR 1** | 0.0025 | 0.9774 | 0.3392 | 0.5978 | 0.8389 | 0.2003 |
| **AR 2** | 0.0002 | 0.5777 | 0.9239 | 0.7388 | 0.7959 | 0.6519 |
| **AR 3** | 0.0418 | 0.9047 | 0.8318 | 0.3506 | 0.9685 | 0.7172 |
| **AR 4** | 0.0215 | 0.9686 | 0.5152 | 0.3088 | 0.8235 | 0.5757 |
| **AR 5** | 0.7877 | 0.6150 | 0.0097 | 0.0094 | 0.2927 | 0.6998 |

| **Minimum Information Criterion** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Lags** | **MA 0** | **MA 1** | **MA 2** | **MA 3** | **MA 4** | **MA 5** |
| **AR 0** | -2.44973 | -2.55424 | -2.51246 | -2.4979 | -2.44605 | -2.42616 |
| **AR 1** | -2.53476 | -2.49457 | -2.45223 | -2.44139 | -2.38597 | -2.36412 |
| **AR 2** | -2.51886 | -2.45895 | -2.39973 | -2.37936 | -2.32401 | -2.3026 |
| **AR 3** | -2.50003 | -2.44154 | -2.37977 | -2.31815 | -2.26451 | -2.24289 |
| **AR 4** | -2.44325 | -2.38707 | -2.32572 | -2.27767 | -2.21564 | -2.18655 |
| **AR 5** | -2.41427 | -2.3601 | -2.30143 | -2.24809 | -2.18712 | -2.12528 |

***Minimum Table Value: BIC(0,1) = -2.55424***

| **ARMA(p+d,q) Tentative Order Selection Tests** | | | | | |
| --- | --- | --- | --- | --- | --- |
| **SCAN** | | | **ESACF** | | |
| **p+d** | **q** | **BIC** | **p+d** | **q** | **BIC** |
| 1 | 0 | -2.53476 | 0 | 1 | -2.55424 |
| 0 | 1 | -2.55424 | 1 | 1 | -2.49457 |
|  |  |  | 2 | 1 | -2.45895 |

*Suggestions of ESACF and SCAN are summarized in above output table, from which we choose model with least BIC ie, p+d = 0 and q= 1 for variable LOAN(1,1).*

*Thus the model selected is ARIMA (0, 2, 1) for LOAN variable, as d is 2 .*

**Step 3: Parameter Estimation**

Results show MA estimate is significant and Mu is insignificant to the model.

| **Conditional Least Squares Estimation** | | | | | |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **Estimate** | **Standard Error** | **t Value** | **Approx Pr > |t|** | **Lag** |
| **MU** | 0.01690 | 0.02161 | 0.78 | 0.4371 | 0 |
| **MA1,1** | 0.38532 | 0.11356 | 3.39 | 0.0012 | 1 |

**Step 4: Diagnostic Checking**: Selected model has least AIC & SBC values shown in below output:

|  |  |
| --- | --- |
| **Constant Estimate** | 0.016899 |
| **Variance Estimate** | 0.082676 |
| **Std Error Estimate** | 0.287534 |
| **AIC** | 25.43314 |
| **SBC** | 29.87215 |
| **Number of Residuals** | 68 |
|  | | |

***Correlation of parameters shows no correlation between estimates suggesting a good model.***

| **Correlations of Parameter Estimates** | | |
| --- | --- | --- |
| **Parameter** | **MU** | **MA1,1** |
| **MU** | 1.000 | 0.003 |
| **MA1,1** | 0.003 | 1.000 |

Check for white noise residuals: Results accept Null Hypothesis that residuals are white noise

| **Autocorrelation Check of Residuals** | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **To Lag** | **Chi-Square** | **DF** | **Pr > ChiSq** | **Autocorrelations** | | | | | |
| **6** | 4.76 | 5 | 0.4464 | -0.022 | 0.029 | 0.124 | -0.084 | -0.045 | -0.193 |
| **12** | 10.30 | 11 | 0.5032 | -0.035 | -0.144 | -0.086 | 0.161 | 0.113 | 0.014 |
| **18** | 13.09 | 17 | 0.7300 | 0.140 | 0.068 | -0.004 | 0.058 | 0.001 | -0.062 |
| **24** | 18.22 | 23 | 0.7454 | -0.098 | -0.080 | 0.131 | -0.116 | 0.011 | 0.063 |



The normal and quantile distribution plots for the residuals suggest that the residuals are normally distributed.



Final Model:

| **Model for variable LOAN** | |
| --- | --- |
| **Estimated Mean** | 0.016899 |
| **Period(s) of Differencing** | 1,1 |

| **Moving Average Factors** | |
| --- | --- |
| **Factor 1:** | 1 - 0.38532 B\*\*(1) |

**Summary:**

* *LOAN variable is non-stationary.*
* *LOAN (1) - First order difference is also non-stationary.*
* *LOAN (1, 1) - The second order differencing results in a stationary time series, with Autocorrelation check results reflecting white noise.*
* *From suggestions of ESACF and SCAN, model with least BIC is chosen ie, p+d = 0 and q= 1 for variable LOAN(1,1).*
* *Thus the model selected is ARIMA (0, 2, 1) for LOAN variable, as d is 2 .*
* *Results of parameter estimation show MA estimate is significant and Mu is insignificant to the model.*
* *Correlation of parameters shows no correlation between estimates suggesting a good model.*
* *Check for white noise residuals: Results accept Null Hypothesis that residuals are white noise*
* *The normal and quantile distribution plots for the residuals suggest that the residuals are normally distributed.*