Stevens Institute of Technology

School of Business

**AACSB  
ASSURANCE OF LEARNING**

**Master of Science in Financial Analytics**

**(FA)**

**LEARNING GOAL #4**

**Students will be able to develop predictive forecasts using historical data.**

**Responsibility:** Zachary Feinstein

May 2021

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# 1. INTRODUCTION: LEARNING GOAL #4

Goal: Students will be able to develop predictive forecasts using historical data.

Students will be expected to take various time series models and use them to develop predictive models. These students will be evaluated on their ability through their performance in FA542, with later reevaluations based on their performance later.

# 2. LEARNING OBJECTIVES AND TRAITS

|  |  |
| --- | --- |
| **Learning Goal 4: Students will be able to develop predictive forecasts using historical data.** | |
| **Objective 1:** *Students will be able to calibrate models based on historical data* | |
| **Traits** |  |
| Trait 1: | Calibrate models based on ARMA models |
| Trait 2: | Calibrate models based on ARCH models (ARCH, GARCH, etc.) |
| **Objective 2:** *Students will be able to create a forecast using established parameters.* | |
| **Traits** |  |
| Trait 1: | Develop the mean forecast |
| Trait 2: | Develop the standard error of the forecast |

# 3. RUBRICS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Objective 1** | *Students will be able to calibrate models based on historical data* | | | |
|  | **Trait** | **Poor** | **Good** | **Excellent** |  |
|  | **Value** | **0** | **5** | **10** |  |
| Trait 1: | Calibrate models based on ARMA models | Limited command of techniques used in this area | Good command of techniques used in this area | Strong command of techniques used in this area |  |
| Trait 2: | Calibrate models based on ARCH models (ARCH, GARCH, etc.) | Limited command of techniques used in this area | Good command of techniques used in this area | Strong command of techniques used in this area |  |
| **Objective 2** | *Students will be able to create a forecast using established parameters.* | | | |
|  | **Trait** | **Poor** | **Good** | **Excellent** |  |
|  | **Value** | **0** | **5** | **10** |  |
| Trait 1: | Develop the mean forecast | Limited command of techniques used in this area | Good command of techniques used in this area | Strong command of techniques used in this area |  |
| Trait 2: | Develop the standard error of the forecast | Limited command of techniques used in this area | Good command of techniques used in this area | Strong command of techniques used in this area |  |

**Criterion: Score below 20 is “below expectations”; between 20 and 30 is “meets expectations”; and greater than 30 is “exceeds expectations**



# 4. ASSESSMENT PROCESS

|  |  |  |
| --- | --- | --- |
| **Where & when measured?** | **How measured?** | **Criterion** |
| Assessed in the spring in FA542 Financial Time Series | Based on the students’ performance on homeworks and exams in the class. | 85% of students get a grade of Meets expectations or better on the final assessment. |

# 5. RESULTS OF LEARNING GOAL ASSESSMENT - INTRODUCTION

The results of the initial learning goal assessments carried out to date are included below.

**Explanation of Direct Measurements**

The students’ performance will be evaluated based on their performance on homeworks and exams. Certain problems from each assignment/exam will be used to evaluate particular objectives.

**Explanation of Indirect Measurements**

Indirectly assessed for some students through mock interviews. They are also assessed indirectly through competitions our students participate in. For example, every spring the Hanlon Center organizes the Algorithmic Trading Competition and many students participate in it. We further assess these goals through alumni surveys, advisory council feedback, employer input, and career fair feedbacks.

# 6. Assessment Spring 2022:

NOTICE THAT THE DIRECT ASSESSMENT IS DONE FOR ON CAMPUS; WEBCAMUS AND COMBINED THIS IS NOW A REQUIREMENT FOR AOL

WE WILL START ASSESSMENTS IN FALL OF 2021

## The direct measurement is performance in the class

1. Indirect measurement is used periodically. Indirectly assessed for some students through mock interviews. They are also assessed indirectly through competitions our students participate in. For example, every spring the Hanlon Center organizes the Algorithmic Trading Competition and many students participate in it. We further assess these goals through alumni surveys, advisory council feedback, employer input, and career fair feedbacks.

# RESULTS OF ASSESSMENT: Spring 2022

**LEARNING GOAL #1:**   
*Students will be able to develop predictive forecasts using historical data.*

**LEARNING OBJECTIVE #1:**   
*Students will be able to calibrate models based on historical data*

**ASSESSMENT DATE: May 16, 2022**

**ASSESSOR: Zachary Feinstein**

**NUMBER OF STUDENTS: 35  
COURSE: FA542**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Number of Students** | | |  |
| **Learning Goal Traits** | **Not Meet Expectations** | **Meets Expectations** | **Exceeds Expectations** | **Average Grade** |
| 1: Calibrate models based on ARMA models | 2 | 10 | 23 | 8.00 |
| 2: Calibrate models based on ARCH models (ARCH, GARCH, etc.) | 2 | 3 | 30 | 9.00 |
| **Average Grade (Out of 10) =** | | | | 8.50 |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Not Meet Expectations** | **Meets Expectations** | **Exceeds Expectations** |
| **Total Students by Category**  *(Based on average score across all traits)* | 1 | 11 | 23 |

**COMMENTS:** Students explored different time series models using data to calibrate those models. This was accomplished using R programming on financial market data. Students struggled with multivariate modeling when they had to model two series simultaneously; this was considered with vector autoregressive models (Trait 1). Using R packages and following sample code from the textbook and provided within the course, students excelled with ARCH models (Trait 2).

**REMEDIAL ACTIONS:**

* Provide additional sample code for multivariate models so that students understand the distinctions between multivariate and univariate models.
* Include consistent data set throughout the semester that students can use to compare models as we progress through the course.

**LEARNING OBJECTIVE #2:**   
*Students will be able to create a forecast using established parameters.*

**ASSESSMENT DATE: May 16, 2022**

**ASSESSOR: Zachary Feinstein**

**NUMBER OF STUDENTS: 35**

**COURSE: FA542**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Number of Students** | | |  |
| **Learning Goal Traits** | **Not Meet Expectations** | **Meets Expectations** | **Exceeds Expectations** | **Average Grade** |
| 1: Develop the mean forecast | 4 | 12 | 19 | 7.14 |
| 2: Develop the standard error of the forecast | 9 | 14 | 12 | 5.43 |
| **Average Grade (Out of 10) =** | | | | 6.29 |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Not Meet Expectations** | **Meets Expectations** | **Exceeds Expectations** |
| **Total Students by Category**  *(Based on average score across all traits)* | 5 | 18 | 12 |

**COMMENTS:** Students utilized different modeling techniques for forecasting time series. For linear time series models, both theoretical and Monte Carlo approaches were considered. For nonlinear time series models, Monte Carlo approaches were emphasized. Students performed well with the theoretical mean forecast for linear time series models but had more difficulty (but still met expectations) with Monte Carlo approaches (Trait 1). There were significantly more difficulties for the standard error of the forecast, especially for multi-step ahead forecasting (Trait 2).

**REMEDIAL ACTIONS:**

* Provide more sample code for Monte Carlo simulations for forecasting (mean and standard error).
* Emphasize formulas for multi-step ahead forecasting in linear models early in the semester. Currently this was only provided at the end of a lecture and may have been overlooked by students on review.

# 7. Outcomes from Previous Assessments:

The following table shows the average scores on each goal objective.

|  |  |  |
| --- | --- | --- |
|  | Objective 1  *Students will be able to calibrate models based on historical data* | Objective 2  *Students will be able to create a forecast using established parameters.* |
| Spring 2022 | 8.50 | 6.29 |

# 8. Close Loop Process – Continuous Improvement Record

Assurance of Learning

Assessment/Outcome Analysis

Close Loop Process - Continuous Improvement Record

**Program:** Master of Science in Financial Analytics

**Goal 4:** Students will be able to develop predictive forecasts using historical data.

**Goal Owner:** Zachary Feinstein

**Where Measured:** Students are assessed in the fall in the required course:

FA542 Time Series with Applications to Finance

**How Measured:** Based on student performance in the class

**Closing the Loop: Actions taken on specific objectives**

|  |  |
| --- | --- |
| **Objective 1** | *Students will be able to calibrate models based on historical data* |
| **When Assessed:** | *Spring 2022* |
| **Remedial**  **Action** | * Provide additional sample code for multivariate models so that students understand the distinctions between multivariate and univariate models. * Include consistent data set throughout the semester that students can use to compare models as we progress through the course. |
| **Outcome from previous assessment** |  |
| **Objective 2** | *Students will be able to create a forecast using established parameters.* |
| **When Assessed:** | *Spring 2022* |
| **Remedial**  **Action** | * Provide more sample code for Monte Carlo simulations for forecasting (mean and standard error). * Emphasize formulas for multi-step ahead forecasting in linear models early in the semester. Currently this was only provided at the end of a lecture and may have been overlooked by students on review. |
| **Outcome from previous assessment** |  |

**Appendix: Assignments for Evaluation**

**Objective 1:**

**Trait 1:**

Homework 5

FA-542

Due: April 27, 2022 at 5PM

**Problem 1** (75pt)

The Federal Reserve Bank of St. Louis publishes selected interest rates and U.S. financial data on its website: [http://research.stlouisfed.org/fred2/.](http://research.stlouisfed.org/fred2/) Consider the monthly 1-year (DGS1) and 10-year Treasury (DGS10) constant maturity rates from January 1962 through December 2021; see the file **homework05.csv**. The rates are in percentages. Let *ct* = *rt − rt−*1 be the change series of the monthly interest rate *rt*.

1. Construct single time series autoregressive models for the single time series *c*1 and *c*10.

*t t*

1. Build a *bivariate* autoregressive model for the two change series.
2. Transform the constructed bivariate model into a structural form.
3. Briefly discuss the implications of the vector autoregressive model and compare with the single time series models.

**Trait 2:**

Homework 3

FA-542

Due: March 6, 2022 at 5PM

**Problem 1** (50pt)

In R create a report in pdf format using RMarkdown (or, if you choose to use Python instead, create a Jupyter notebook) to:

1. Download daily price data for January 1, 1987 through December 31, 2021 of Microsoft stock from Yahoo Finance. You may use the quantmod package in R for this purpose.
2. Is there any evidence of serial correlations in the *monthly* log returns. Use autocor- relations and 5% significance level to answer the question. If yes, remove the serial correlations.
3. Is there any evidence of ARCH effects in the monthly log returns? Use the residual series if there are serial correlations in part (ii). Use Ljung-Box statistics for the squared returns (or residuals) with 6 and 12 lags of autocorrelations and 5% significance level to answer the question.
4. Identify an ARCH model for the data and fit the identified model. Write down the fitted model and justify your choice of parameters.

**Objective 2:**

**Trait 1 + 2: Underlined questions**

Homework 2

# FA-542

Due: February 27, 2022 at 5PM

**Problem 1** (30pt)

Suppose that the daily log return of a security follows the AR(2) model:

*rt* = 0*.*1 *−* 0*.*5*rt−*2 + *at*

where *at* is a Gaussian white noise series with mean zeros and variance 0*.*2. (i)What are the mean and variance of the return series *rt*?

1. Compute the lag-1 and lag-2 autocorrelations of *rt*.
2. Assume that *r*100 = 0*.*2 and *r*99 = 0*.*05. Compute the 1- and 2-step ahead forecasts of the return series at the forecast origin *t* = 100. What are the associated standard deviations of the forecast errors?
3. In R create a report in pdf format using RMarkdown (or, if you choose to use Python instead, create a Jupyter notebook) to:
   1. Simulate 1000 terms of this time series with *r*0 = 0*.*2 and *r−*1 = 0*.*05.
   2. Using the generated time series, find the sample mean and variance. How do these values compare with those computed analytically?
   3. Using the generated time series, find the sample lag-1 and lag-2 autocorrelations.

How do these values compare with those computed analytically?

* 1. Consider how you might use repeated simulations to forecast this time series. Use your method with 1000 repeated simulations of the time series to forecast the 1- and 2-step ahead returns with *rt* = 0*.*2 and *rt−*1 = 0*.*05. What is the sample standard deviation? How do these values compare with those computed analytically?

**Problem 2** (30pt)

Suppose that the simple return of a monthly bond index follows the MA(1) model:

*Rt* = *at −* 0*.*1*at−*1

where *at* is a Gaussian white noise series with mean zero and variance 0*.*01. (i)What are the mean and variance of the return series *Rt*?

1. Compute the lag-1 and lag-2 autocorrelations of *Rt*.
2. Assume that *a*100 = 0*.*01. Compute the 1- and 2-step ahead forecasts of the return series at the forecast origin *t* = 100. What are the associated standard deviations of the forecast errors?
3. In R create a report in pdf format using RMarkdown (or, if you choose to use Python instead, create a Jupyter notebook) to:
   1. Simulate 1000 terms of this time series.
   2. Using the generated time series, find the sample mean and variance. How do these values compare with those computed analytically?
   3. Using the generated time series, find the sample lag-1 and lag-2 autocorrelations.

How do these values compare with those computed analytically?

* 1. Consider how you might use repeated simulations to forecast this time series. Use your method with 1000 repeated simulations of the time series to forecast the 1- and 2-step ahead returns with *at* = 0*.*01. What is the sample standard deviation? How do these values compare with those computed analytically?

**Problem 3** (40pt)

In R create a report in pdf format using RMarkdown (or, if you choose to use Python instead, create a Jupyter notebook) to:

1. Import the monthly yields of Moody’s Aaa seasoned bonds from January 1962 to De- cember 2021 from **homework02.csv** provided on Canvas. The data are obtained from the Federal Reserve Bank of St. Louis. Monthly yields are averages of daily yields.
2. Obtain the summary statistics (sample mean, standard deviation, skewness, *excess*

kurtosis) of this yield series.

1. Build a time series model for this data. Evaluate its performance. Justify your choices.