Course 7 Applied Actuarial Modeling

SAMPLE PRE-TEST
True or False Questions

1-10 Each of Questions 1 through 10 consists of individual statements on various topics. Please indicate whether the statements are TRUE or FALSE by blackening the appropriate space on your answer sheet.

1. When a model is formulated from and fitted to the same data, inferences made from it will be biased when they ignore the data analytic actions that preceded the inference.
   
   (A) True
   (B) False

   ANSWER: A

2. Data exhibiting stable trends with much random fluctuation about the trends are more predictable than data exhibiting instability in trends and little random variation about the trends.
   
   (A) True
   (B) False

   ANSWER: A

3. In principle, Value at Risk is a one-sided confidence interval.
   
   (A) True
   (B) False

   ANSWER: A

4. The historical approach to deriving a reasonable estimate of volatility to use in an option model uses the actual option price and solves for the volatility rate that will cause the model to produce the observed market price.
   
   (A) True
   (B) False

   ANSWER: B
5. In the context of an actuarial communication, reliance on other sources means making use of those sources without relinquishing responsibility therefor.

(A) True
(B) False

ANSWER: B

6. It is preferred to collect a lot of data first, then use it to construct a theory.

(A) True
(B) False

ANSWER: B

7. Decomposition improves judgmental predictions.

(A) True
(B) False

ANSWER: A

8. Econometric models can be used to forecast changes.

(A) True
(B) False

ANSWER: A

9. When selecting variables for use in an econometric model, stability in the causal variables over time is needed.

(A) True
(B) False

ANSWER: B
10. Each time an actuary provides actuarial advice based on a model with nonactuarial components, a written report is required.

   (A) True
   (B) False

   ANSWER: B

Multiple-Choice Questions

11-19 Questions 11 through 19 consist of an assertion in the left-hand column and a reason in the right-hand column. Choose your answer to each question according to the following:

(A) If both the assertion and the reason are true statements and the reason is a correct explanation of the assertion.
(B) If both the assertion and the reason are true statements, but the reason is a NOT a correct explanation of the assertion.
(C) If the assertion is a true statement, but the reason is a false statement.
(D) If the assertion is a false statement, but the reason is a true statement.
(E) If both the assertion and the reason are false statements.

**ASSERTION**  
REASON

11. The prevailing paradigm can delay the acceptance of new discoveries.  
The prevailing paradigm determines not only what questions are asked but also what kinds of data are considered relevant and how the data will be gathered, analyzed, interpreted and related to theoretical concepts.

   Answer A

12. An important distinction between futurism and other disciplines that deal with the future is its overall approach to uncertainty.  
Standard predictions are action oriented.

   Answer C
13. **ASSERTION** In order to measure the magnitude of the possible error when valuing options, it is important to use a volatility rate that does not accurately reflect market conditions.  

**REASON** There is no single “right” level of volatility to use in valuing options. 

Answer A

14. **ASSERTION** Inputs should be selected carefully.  

**REASON** When model and forecasts are revealed, there is little concern about the inputs.

Answer A

15. **ASSERTION** The estimated standard errors of regression coefficients tend to understate reliability.  

**REASON** Estimated standard errors of regression coefficients are estimated using the same sample that produced the coefficients themselves.

Answer D

16. **ASSERTION** When a model is practically significant but not statistically significant, the model should be rejected.  

**REASON** Both practical and statistical types of significance are needed in order to keep working with a model.

Answer E

17. **ASSERTION** Communicating technical information is difficult. 

**REASON** In most analyses, there is no one “right” answer.

Answer A
18. A report’s interpretation of a model and statement of implications should be stated in non-technical terms.

Reason: The report may be read by many audiences beyond the intended client.

Answer B

19. An actuary who waives his fee is not obligated to disclose that he is acting as an advocate.

Reason: Waiving of a fee relieves the actuary of the need to observe professional standards.

Answer E

20-25 Questions 20 through 25 consist of two lists. In the list at the left are two items, lettered X and Y. In the list at the right are three items, numbered I, II, and III. ONE of the lettered items is related in some way to EXACTLY TWO of the numbered items. Indicate the related items using the following answer code:

<table>
<thead>
<tr>
<th>Lettered Item</th>
<th>Is Related to Numbered Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) X</td>
<td>I and II only</td>
</tr>
<tr>
<td>(B) X</td>
<td>II and III only</td>
</tr>
<tr>
<td>(C) Y</td>
<td>I and II only</td>
</tr>
<tr>
<td>(D) Y</td>
<td>I and III only</td>
</tr>
<tr>
<td>(E)</td>
<td>The correct answer is not given by (A), (B), (C) or (D).</td>
</tr>
</tbody>
</table>

20. X. Old paradigm regarding how systems undergo change

Y. New paradigm regarding how systems undergo change

I. Equations are unstable with respect to initial data.

II. The future of a human system is inherently unpredictable.

III. A fully deterministic system cannot appear completely random.

Answer C
21. X. Intensive research
   Y. Eclectic research
   I. Conducted by a specialist
   II. Can produce an illusion of accuracy
   III. Is inexpensive

Answer A

22. X. Conditional forecast
    Y. Unconditional forecast
    I. Uses only data available at the time
       the forecast is made
    II. Ex post
    III. Ex ante

Answer D

23. X. Cross Impact Analysis
    Y. Trend Impact Analysis
    I. Provides insight into the results of long
       causality chains
    II. May be used to test alternative action
        plans
    III. Ignores the impact of surprising future
         events

Answer A

24. X. Time series data
    Y. Cross-sectional data
    I. Greater independence among the
       observations
    II. Larger variations among the causal
        variables
    III. Inexpensive to obtain

Answer C
25. X. Testing of inputs  
Y. Testing of outputs  
   I. Used for selecting the best model  
   II. Used for improving a model  
   III. Can be used for a cost/benefit analysis

Answer D

26. Place the following steps of the systems approach in order, with < indicating a step that occurs earlier in time.

I. Operational program  
II. Indicators of success  
III. Alternative strategies  
IV. Ultimate objectives

(A) I < II < III < IV  
(B) I < IV < II < III  
(C) III < II < IV < I  
(D) IV < II < III < I  
(E) II < I < III < IV

Answer D

27. A forecast has been based on minimizing the sum of squares of a linear model. Which of the following names is most appropriate from a systems perspective.

(A) Least squares  
(B) Ordinary least squares regression  
(C) A linear forecast equation based on normal errors  
(D) Maximum likelihood estimation  
(E) Econometric forecast

Answer C
28. Which of the following statements is consistent with the systems approach to forecasting?

(A) In initially describing a system, it is important to be as specific as possible.

(B) It is important to spend time on each step in the systems approach, but the appropriate order of the steps is dependent on the specific problem.

(C) The means used to obtain objectives are as important as the objectives themselves.

(D) The most important step in the systems approach is identifying the indicators of success.

(E) It is important to develop multiple strategies for obtaining objectives.

Answer E

29. The term “model selection biases” refers to biases that occur when

(A) a model is chosen on the basis of available software.

(B) goodness-of-fit statistics are not used in selecting a model.

(C) the same data is used to identify a model and to estimate model parameters.

(D) a model is not known a priori.

(E) inappropriate estimation techniques are used.

Answer C

30. Which of the following is an advantage of real-world behavioral trials over mathematical modeling?

(A) Real world trials are generally less expensive.

(B) Real world trials permit generalization over a broader range of conditions.

(C) Real world trials generally minimize the loss of fidelity.

(D) Real world trials permit causal explanations of behaviors of interest.

(E) Real world trials eliminate the need for simplifying assumptions.

Answer C
31. When using historical data, which of the following strategies will NOT increase the reliability of estimates of regression coefficients?

(A) Choose causal variables with a large range of values.
(B) Sample from a large number of historical periods.
(C) Hold factors other than the causal variables constant.
(D) Use the average of multiple measures of the causal variables.
(E) Exclude factors (other than the causal variables) if they vary with the dependent variable.

Answer E

32. You have obtained studies of lapse rates from three organizations. They generally agree with each other. Which of the following best describes the quality of these rates?

A. They have reliability
B. They have construct validity
C. They have face validity
D. They have predictive validity
E. None of A, B, C, or D

Answer B

33. A number of methods can be used to address the problem of model uncertainty. Which of the following procedures is NOT recommended?

(A) Using a second data set for model verification
(B) Doing a sensitivity analyses on model assumptions
(C) Estimating observable quantities rather than parameters
(D) Evaluating models on the basis of usefulness and accuracy
(E) Improving the specificity of models by increasing the number of variables.

Answer E
34. Which of the following techniques is least likely to convince people to implement a new procedure?

(A) Including stakeholders in identifying the problem
(B) Emphasizing the benefits of the procedure
(C) Giving clients control over change
(D) Presenting the new procedure in the form of an experiment
(E) Giving feedback to participants

Answer B

35. Indicators of success should be valid and reliable. In statistical terms match each term in first column with its statistical counterpart in the second column.

X. Valid
Y. Reliable

I. Unbiased
II. Minimum variance
III. Sufficient

(A) X-I and Y-II
(B) X-I and Y-III
(C) X-II and Y-I
(D) X-II and Y-III
(E) X-III and Y-I

Answer A
36. (6 points) Identify and briefly describe general limitations of the modeling process.

36. SOLUTION

General limitations of the modeling process result from the process itself and from the execution of the process. Limitations of the modeling process resulting from the process itself include:

1. some real-world phenomena or behavior are so complex that to construct a model is either virtually impossible or too costly;
2. a model’s use of simplifying assumptions results in lost of fidelity, the preciseness of its representation of reality; and
3. the necessary data to validate or run the model may be unavailable, difficult to obtain, difficult or costly to prepare for use, or unusable – in particular, using the same data to formulate and validate a model can lead to biased inferences.

Limitations of the modeling process resulting from the execution of the process include:

1. inadequate specification of the scope and purpose of the model in advance, which can hinder the development of the model because of efforts to expand the scope or change the purpose;
2. not knowing when and how to apply a model;
3. attempting to apply an existing computational tool to new problems, when what is needed is a more general model;
4. misspecification of the model – for example, bias as a result of the statistical method used to select the model ,or omitting an important variable in formulating the model;
5. failure to implement a model that has been developed; and
6. failure to update the model when the behavior of the modeled phenomena has changed or some factors not considered in the model have become important.
37. (10 points) When forecasting change, there are three types of errors:

a. Errors in estimating the current relationships
b. Changes in the relationships over the forecast period
c. Errors in forecasting changes in the causal variables

It is desired to develop and then use a function which forecasts the incidence of policy loans in terms of the interest rate in the previous quarter. The forecast

\[
policy \ loan \ incidence = 0.1 + (1.2 \times \text{interest rate})
\]

is used to forecast policy loan incidence six quarters from now, based on an interest rate five quarters from now of 0.06. Relate the three sources of error to this forecast.

37. SOLUTION

a. The current relationship is estimated by the coefficients 0.1 and 1.2. Because these numbers were estimated from a sample, they may not match the population values.

b. Both the coefficients and the function itself were selected from current and past data. The future relationship may be different, both with regard to the population values of the coefficients and also the nature of the function. For example, six quarters from now the relationship may be quadratic instead of linear.

c. The causal variable, interest rate, must be forecasted five quarters from now. The forecast of 0.06 may not match the actual interest at that time.
38.  *(6 points)* Identify and briefly describe the key components of the methodology of applied futurism.

38.  **SOLUTION**

The key components of the methodology of applied futurism are:

1. assessing the current state of the system of interest, which includes identifying
   - the system of interest,
   - the domain of observation,
   - when the current state began and how it is different from previous states,
   - the major participants in the system and their relationships,
   - the trends and potential events of the system, and
   - current issues and potential outcomes;

2. projecting alternate future states, which includes
   - defining the time horizon,
   - identifying the projection assumptions, and
   - projecting several future states consistent with the current state of the system;

3. in conjunction with those affected by the system, choosing the future state that best satisfies the needs and values of the those affected by the system, and that is both possible and without undesirable side-effects;

4. developing a detailed strategy to move the system of interest from the current state to the preferable future state;

5. implementing the plan so that the preferable state becomes a reality; and

6. evaluating the results to determine whether or not the system of interest is on track to achieve the desirable future state; that is, monitoring the attributes of the system of interest to determine whether they are approaching the characteristics of the preferred future state.

The results of the evaluation step feed back into the current state assessment, and the process continues through another cycle. Several cycles of the methodology are completed until the preferable future is achieved.
SOLUTION

The process of model validation addresses the following questions:

1. Does the model answer the problem for which it was developed?
2. Is the data necessary to operate the model available?
3. Does the model contain any mathematical errors or faulty assumptions?

Testing model inputs relates to all three questions. Testing inputs helps eliminate faulty assumptions and improve the model. Inputs to a model include the model building process, the variables and the relationships in the model. Inputs should be tested for validity and reliability. Tests for validity may be classified into three categories: face validity, predictive validity and construct validity. The test of face validity is whether “people who should know” agree that something is reasonable, and is the weakest of the validity tests. Predictive validity, as applied to the model inputs, considers whether the inputs are valid for the problem being addressed by the model. Construct or conceptual validity considers whether a measurement measures what it claims to measure and is tested by using different measurement methods and comparing the results. The test of reliability asks whether another researcher can follow the specific process and obtain the same results.

Testing model outputs can be used to gain further insight about the inputs to a model so that improvements can be made; however, the major reason for testing outputs is to make comparisons among a set of models. In testing model outputs, the testing situation should be as similar as possible to the forecasting situation with respect to space (i.e. the environment of the forecasting problem), population (i.e. the decision units of the forecasting problem) and time. With respect to time, three time periods are important. Data from the time period immediately preceding the current time can be withheld to test forecast validity. Data from the time period immediately preceding that one can be used to calibrate the model and test for concurrent validity. Finally, data from the next earliest time frame can be used for a test of backcast validity.

Accuracy of model outputs is of major concern. A single measure of accuracy may fall short. Measures of accuracy include mean error, mean absolute deviation, coefficient of variation, coefficient of determination and accuracy ratio.

Key considerations in comparing for accuracy model results to actual data from empirical observations include:

1. the data used for comparison should not be the same data as was used in formulating the model,
2. the comparison should include observations over the same range of values of the independent variables as may be encountered when actually using the model,
3. the degree of accuracy that is acceptable,
4. the statistical significance of the differences (i.e. not likely to have occurred by chance), and
5. the practical significance of the differences (i.e. importance to decision-making).

The end result of the testing is that the model may be deemed to be satisfactory and useful or it may require refinement or simplification.
40. (10 points) Consider the following table of forecasted and actual results:

<table>
<thead>
<tr>
<th>Time</th>
<th>Forecast</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>105</td>
</tr>
<tr>
<td>2</td>
<td>110</td>
<td>112</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>119</td>
</tr>
<tr>
<td>4</td>
<td>130</td>
<td>133</td>
</tr>
<tr>
<td>5</td>
<td>140</td>
<td>139</td>
</tr>
</tbody>
</table>

Calculate the ME (mean error), the MAD (mean absolute deviation), the RMSE (root mean square error), the MAPE (mean absolute percentage error), and the CV (coefficient of variation).

**SOLUTION**

\[
\text{ME} = \frac{5 + 2 - 1 + 3 - 1}{5} = 1.6
\]
\[
\text{MAD} = \frac{5 + 2 + 1 + 3 + 1}{5} = 2.4
\]
\[
\text{RMSE} = \sqrt{\frac{25 + 4 + 1 + 9 + 1}{5}} = 2.8284
\]
\[
\text{MAPE} = \frac{100(5/105 + 2/112 + 1/119 + 3/133 + 1/139)/5 = 2.0726}{2.8284/[(105 + 112 + 119 + 133 + 139)/5]} = 2.0726
\]
\[
\text{CV} = \frac{2.8284}{[(105 + 112 + 119 + 133 + 139)/5]} = 2.8284/121.6 = 0.02326
\]
41. **(6 points)** Describe the important considerations in evaluating the quality of user input.

41. **SOLUTION**

Important considerations in evaluating the quality of user input include:

1. use of the correct data elements, given the intended analysis,
2. comprehensiveness of the data, including the level of detail required to produce results consistent with the intended use of the model,
3. appropriateness of the data— the user input should not only be reasonably free from errors, but also should be appropriate for the problem under study and sufficiently current, and
4. reasonableness of the data, including internal and external consistency.

Guidelines to follow in the assessment of the comprehensiveness, appropriateness and reasonableness of user input include:

1. know the source of the data and why and how the data was originally captured, which should help make an initial assessment of the appropriateness of the user input,
2. understand the incentives inherent in the data’s original use, which can impact the volume and accuracy of the data,
3. if data is in electronic format, printout and examine several records for reasonableness since a potential problem with electronic data is the difficulty in looking at the details of the data,
4. have an expectation of the distribution of the data and compare the expectation with the data,
5. check for blank or duplicate records,
6. double check the definition of critical data items,
7. spot check the data for internal consistency, and check data totals for reasonableness relative to external data sources to the extent possible.
42.  *(10 points)* Graph 1 was developed from Table 1. Graph 1 will be used in a report. Table 1 will not be presented in the report. The trends for each employee classification type over the time period are relevant to the report. Identify four methods of making the graph more effective, and sketch a graph that incorporates these methods.

Table 1

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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<td>1230</td>
<td>1250</td>
</tr>
<tr>
<td>Management</td>
<td>300</td>
<td>250</td>
<td>240</td>
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<td>220</td>
</tr>
<tr>
<td>Executive</td>
<td>50</td>
<td>60</td>
<td>70</td>
<td>80</td>
<td>90</td>
</tr>
</tbody>
</table>

Graph 1

42.  SOLUTION

These methods could be used to make the graph more effective:

1. Use of a three-dimensional stacked bar chart is a poor graphical form for making comparisons over time. It results in “chart junk” and a very low data-ink ratio. An alternative graphical form should be chosen.
2. The truncated scale is inappropriate. The continuing decline in the number of management employees is obscured by the graph, as is the comparative magnitude of the increases in the number of clerical vs. executive employees. The change in total number of employees is magnified.
3. The use of a graph that is on a diagonal results in further making comparisons difficult.
4. Axes labels should be clear and easy to read (e.g. no abbreviations or vertical positioning). Graph titles should summarize the purpose of the graph; in this case the title should include the time factor.

*One of the following graphs would be an appropriate representation of the suggested methods.*

43. SOLUTION

Comments:

1. The title should be concise and to the point. This title is not. Shorten the title. Titles should always be less than 120 characters including spaces.
2. Titles should be comprehensible. This title is not. Reading the title should tell the reader what will come in the report. How do you determine the actuarial soundness of Current Year Asset Investment?
3. The title contains deadwood. Remove the phrase “A Complete Analysis of”.
4. Titles should be accurate. It is highly doubtful that any analysis is “Complete” so even if you leave in the deadwood, the word Complete should be eliminated.

END OF SAMPLE PRE-TEST