Background. The Forecasting Environment. GLOBL (a fictitious company) is one of the leading international companies providing consumer technology products to a broad range of worldwide customers. GLOBL's mission is to provide:

- Development, manufacturing, and sales of educational technology products
- Development and sales of the hardware and software systems to support these products
- A broad range of customer-support services ranging from installations, training, consulting, and ongoing maintenance.

You have just joined GLOBL as a forecaster. You have received some onsite training and have visited various overseas offices to learn about the scope of the job, which is extensive. Your responsibilities are to provide forecasting services to all GLOBL business areas. You must appropriately serve all aspects of GLOBL business, including planning for demand and supply, marketing, sales and operations, finance, new product development and introduction, and corporate strategy. Your manager has observed that, as with any business function, there are not nearly enough forecasting resources to address all the potential needs at GLOBL. Thus, careful evaluation and prioritization of forecasting work activities must be done. Also, there is a great opportunity to become more efficient by better coordinating some of the forecasting services now separately performed for each GLOBL business area.

Your initial assignment is to the demand/supply planning area of GLOBL. And your first product forecasting responsibility is a set of high-tech consumer products. However, over the first 5 years in their careers, it is usual in GLOBL for forecasters to be rotated through several diverse product and services assignments – as well as different aspects of particular business areas.

Your job description as GLOBL demand forecaster includes:

- Forecasting the demand for a group of GLOBL's products
- Providing regular coordinated communications with the development, sales, and marketing groups
- Developing reliable modeling approaches to predict sales volumes
- Providing periodic, objective, defensible forecasts to the sales and operations (S&OP) process, which will use this forecast for production and capacity planning over the subsequent 6 months
- Providing monthly forecast updates and related information for revenue planning
- Presenting and defending forecasts to senior management, as required
- Reviewing forecasting performance on a regular basis with your user groups and information sources to identify areas needing improvement

Although GLOBL develops, manufactures, and sells a broad range of consumer products, you have three product lines for which you will develop forecasts.

Product Line A: This is a family of consumer products for early childhood development. The customers for these products are preschool children who are physically challenged. Their needs are for educational toys, games, and devices that allow them to better adapt to their environment and enhance their growth potential within the community.

Product Line B: This is a family of consumer products for academia and institutions of higher learning. The customers for these products are students requiring specialized learning devices and educational materials to allow them to cope more effectively and competitively in a general academic environment.

Product Line C: This is a family of consumer products for the occupationally challenged. The customers for these products are adults in the workforce requiring customized aids for enhancing their productivity in the workplace.

The Marketplace for GLOBL Products. There are five major players in the world-wide educational technology marketplace, plus another dozen niche players. GLOBL has a centralized market intelligence staff that are responsible for overall marketplace trends and outlooks, keeping track of competitie activities and market share, and performing specialized marketplace studies as required by sales, marketing and product development.

GLOBL Product Development. GLOBL does all development work on the three products you will be forecasting. This means that GLOBL maintains a development staff whose responsibilities include evaluating and tracking customer requirements for educational products, determining and prioritizing what needs may be best pursued by GLOBL, designing and developing products to meet these needs, determining go-to-market strategies for these products, tracking GLOBL product performance versus objectives, and enhancing products as required to meet GLOBL objectives.

GLOBL Sales Force and Channel Strategy. GLOBL has a worldwide team of dedicated product sales specialists. There are also a number of business partners who sell GLOBL products, often along with other products and services. There is a strong focus on increasing the use of web-based facilities to exploit e-business sales.

GLOBL Manufacturing. GLOBL performs manufacturing activity for the products you forecast. Worldwide manufacturing supply/demand planning is performed centrally for all products, although there are several manufacturing sites for each product.

GLOBL Product and Strategy Details

Product Line A: Product Line A sells into the preschool market. In recent years, Product Line A has seen dramatically increased use to support web-based applications**.**

Product Line B: Product Line B sells into the academic market and institutions of higher learning. Although GLOBL has been in the market for quite a few decades, the original versions of this line were introduced just over 36 months ago. Sales have been normal for the past year. Two years ago, there was an unexpected upswing in demand in Quarter 3, which caused big manufacturing problems. A dedicated sales force does over 90% of sales and has grown significantly in size over the past 3 years. There are currently plans for a further strengthening of the sales budget due to concern that GLOBL is still number 3 in this marketplace. This sales force operates off a quota system with sales contests scheduled approximately once a year, usually in the last quarter.   Selling   in   this marketplace depends on establishing good relationships with the educational institutions. GLOBL's

competitors appear to be more successful at this. You have difficulties getting solid information on the product line's sales activities from the sales force.

Product Line C. Product Line C sells into the commercial workplace market. It spans a wide range of occupational functions in industry, supporting complex needs across many business applications. Product Line C has seen modest growth over the past several years; new and esoteric applications in many commercial marketplaces are driving a niche market. GLOBL has divided its sales efforts between its own sales force and its business partners in roughly a 30 – 70 split. Good contacts with traditional customers have been key to sales success. However, forward-looking strategists are beginning to be concerned regarding the trends to mutual e-procurement initiatives in these customers.

Step 1: Prepare the Factors.

GLOBL has determined a number of factors that influence the demand for its products. These factors may be different across the product lines, but six factors appeared to have some common value. Unfortunately, these factors often display some similarities in their strength of impact on the demand. It is your responsibility to sort out the behavior of these factors and their influence on demand in order to obtain some quantification of this for presentation to your management. You came up with the idea of an association matrix for the factors. In this exercise, we create such a matrix.

Factor A. **Opportunity momentum index**: Because each sales situation can be characterized by its sell cycle status, win probability, revenue, and so forth, an index of opportunity momentum was created to measure the goodness of a sales opportunity by the end of its sales cycle.

Factor B. **Competitive pricing index**: Price levels for the product were tracked and compared against similar competitive product.

Factor C. **Product attractiveness index**: Product functionality was indexed with those of its major competitors.

Factor D. **Channel investment index**: This is the percentage of advertising/marketing spending on GLOBL product line as a percentage of total spend by business partners.

Factor E. **Industry investment index**: This is the industry expenditures on web-based applications as a percentage of total industry expenditures on applications.

Factor F. **Gross internet product**: This is a measure, like the GDP, measuring e-industry output.

Question: *Suggest and define three factors for each product line to supplement factors A - F.*

Step 2: Execute an Impact Change Matrix for the Factors Influencing Product Demand.

An *impact change matrix* is a table in which a measure of the impact on demand (during a time period relative to the current time period) is provided for each factor over a number of periods in the product's life cycle. This measure is on a scale of 1 to 5 (**1** = weaker, **2** = moderate, **3** = average, **4** = positive, **5** = stronger). The table is completed as follows.

1. In Prior Year column, place the measure that reflects the change of the factor's impact on demand a year ago relative to its impact in the current period.
2. In Immediate Past column, place the measure to reflect the change of impact the factor has had on demand in the past 3 – 6 months relative to its impact in the current period.
3. In Current Period, place the measure of impact the factor has on demand during the current period.
4. In the Immediate Future column, place the measure to reflect the change of impact the factor is expected to have on demand in the *next* 3 – 6 months relative to its impact in the current period.
5. In Next Year column, place the measure that reflects the change of the factor's expected impact on demand next year relative to its impact in the current period.

The accompanying table is an example of an impact change matrix for a product line under a given set of assumptions about the business environment for GLOBL.

Factor	Prior Year	Immediate Past	Current Period	Immediate Future	Next Year	Comments
A	3	3	4	4	5	Index becoming more reliable
B	3	4	4	5	5	Index becoming more important as products are less differentiated
C	5	3	4	3	4	Competition has substantially caught up with GLOBL
D	1	2	3	3	3	Importance of larger customer is diminishing
E	4	4	3	4	3	Gradually decreasing importance as product lifecycle is ending
F	4	4	4	4	5	Index is expected to increase in importance as the e-market matures

Question: *Using assumptions about the GLOBL environment for the product lines, create impact change matrices. There are no unique answers to this.*

Step 3: Evaluate the Results in the Association Matrix for the Chosen Factors.

An *association matrix* is a table of correlations of the sequences in the impact change matrix. Because these sequences are very short, the ordinary correlation coefficient may not be adequate.

Hence, we have used a robust correlation coefficient that is analogous to the ordinary correlation coefficient. It is described in Appendix 3A. Note that the association of a factor with itself is always unity (= 1) and that the values can range between –1 and +1. The completed association matrix for the example matrix in Step 2 is given next.

	A	B	C	D	E	F
A	1					
B	0.80	1				
C	0.0	-0.72	1			
D	0.80	0.95	-0.28	1		
E	-0.80	-0.34	-0.47	-0.70	1	
F	0.60	0.38	0.18	0.18	-0.18	1

Aside from the direction of impact (positive or negative) on demand, there is a changing pattern of impact over time. When two factors display a similar *pattern of impact* on demand, these factors will be strongly associated. This high association can be positive or negative depending on whether the similarities in patterns move in the same or opposite directions. The importance of these associations may play out when you create models for demand over time using one or more of these factors. Having an early understanding of and insight into this will help you with the modeling issues.

15.3 Using assumptions about the GLOBL environment for your product lines, evaluate the association matrices for the factors of your choice. This is a quantification of a subjective process to give specificity to your assumptions.

Step 4: Reconcile the Association Matrix Results with Your Plans for Developing Demand Models for Your Product Lines Based on These Factors. Factor F, showing low association with several other factors, might be used together with one or more good factors in a regression model. If this is successful, Factor F will be a good factor to use because its impact changes appear to be dissimilar from the others, thus providing a more independent influence on demand.

Questions:

    a.   Reconcile the results found in step 3 with the assumptions you made about the role of the factors in forecasting the demand for your product lines.

    b.   Factors A and E are strongly negatively associated. What implication does this have for their future inclusion in modeling demand for the product?

    c.   Factor A is strongly associated with most of the other factors. Why might this be so? Does it suggest that the other factors should not be included in a demand model for the product that contains Factor A?

Modeling Demand

Step 1: Prepare a Preliminary Analysis of the Product Line and Factors Influencing Demand.

Question: A seasonal decomposition.

    a. Create an analysis of a product line series by identifying the trend and seasonal components with the technique(s) of your choice. Summarize your results in a data sheet like the one given here for future use in reconciling multiple projection techniques.

    b. Answer the following questions and in doing so apply a projection technique to come up with a four-period forecast (horizon = 4 months).

         i. Find the twelve seasonal factors

        ii. Determine the peak seasonal month

      iii. Determine the lowest seasonal month

      iv. Do you notice any subpatterns (e.g. quarter by quarter)?

       v. What is the average monthly change in trend (in level and percent)?

      vi. Determine a projected trend over the forecast horizon

     vii. Determine the projected seasonal factors for the months in the forecast horizon

    viii. Calculate a projection of demand over the forecast horizon

Sample Data Sheet: A Trend*Seasonal Decomposition for Product XYZ

```
          Seasonal Indices  (Multiplicative)
Period  Index
          1     0.279606
          2     0.708010
          3      1.30809
          4     0.794871
          5      1.09598
          6      1.87311
          7     0.921522
          8      1.05525
          9     0.928185
         10     0.579209
         11     0.781690
         12      1.67447

          Accuracy of Model
         MAPE:     75.6
         MAD:      88.9
         MSD:   17831.7
```

```
Row CombSale   TREN1   SEAS1    DETR1   DESE1    FITS1    RESI1

31    230   514.440 0.92152  0.44709   249.59   474.07 -244.068
32    605   533.780 1.05525  1.13343   573.32   563.27   41.726
33    965   553.119 0.92819  1.74465  1039.66   513.40  451.603
34    450   572.459 0.57921  0.78608   776.92   331.57  118.427
35    460   591.798 0.78169  0.77729   588.47   462.60   -2.603
36    765   611.138 1.67447  1.25176   456.86  1023.33 -258.331
```

Model Projections

```
Row Period  Projection
 1    37   176.29
 2    38   460.08
 3    39   875.32
 4    40   547.27
```

Question: Correlation analysis with the factors. *Answer the following questions for each product line in the order that they appear below. In doing so, you will be creating scatter plots and the correlation measures for these factors.*

    a. *Create time plots for the factors.*

    b. *Create scatter plots for the factors.*

Scatter plot	Degree of scatter	Direction of scatter	Visually interpret linear association (-1, +1)
Factor A	Very narrow	Positive	0.8
Factor B	Narrow	Negative	-0.6
Factor C	Broad		0.3
Factor D	--------		
Factor E		--------	

    c. *Determine the correlation coefficient as a measure of association using the table above as a guide.*

	Factor A	Factor B	Factor C	Factor D	Factor E
Factor A	XXXXXXX				
Factor B		XXXXXXX			
Factor C			XXXXXXX		
Factor D				XXXXXXX	
Factor E					XXXXXXX

    d. *Calculate the robust alternative as a measure of association. The robust alternative is like an insurance policy. If the robust alternative is equal or very close to the correlation coefficient, then we have assurance of the validity of the correlation coefficient.* (See L&C, pp. 425-26 for an example.) *However, when there are unusual values in the*

scatter diagram, the correlation coefficient is a deficient and unreliable measure of association. In such situations, the robust alternative and the correlation coefficient are not close. This can provide a valuable warning to the analyst to probe deeper into the nature of the deficiency.

Step 2: Execute Univariate and Multivariable Models for Product Lines

An analysis of each Product has been run creating time plots and scatter plots for factors A – E. Answer the following questions in the order that they appear. In doing so, you will be creating scatter plots and the association/correlation measures for these factors with each Product.

Question: Regression analysis. *Regression analysis determines whether one set of data (one or more independent variables) has any relationship, or correlation, to another set of data (dependent variable). You can make predictions once you calculate these relationships. You collect data for a period of time or from multiple sites so you can perform a regression analysis. You can predict future sales (dependent variable) based on the values specified for the key factors (independent variables) if the correlation between the key factors and sales is strong enough.*

  a. *What is your dependent variable and which factors will you be using for independent variables?*

  b. *Build simple linear regression models for each product with one of its factors. Determine the equation and use the equation to project product demand for a particular value of the factor. Estimate a range.*

Example: Building a simple linear regression model for Product XYZ demand versus Factor A. A regression with Product XYZ demand (dependent variable) against Opportunity Pipeline factor (independent variable) was run with the following results.

  i. Regression output summary:

Constant	-46.9
Std error of Y Estimate	120.5
R^2	0.79
Number of observations	34
X coefficient(s)	1.20

  ii. *Determine the equation*. Answer: The equation is **ProdXYZ demand = - 46.9 + 1.20 (Factor A)**

  iii. *Use the equation to project ProdXYZ Demand if Factor A = 600*. Answer: **ProdXYZ demand = - 46.9 + 1.20 (600) = 673.1 = 673**

  iv. *What is the estimated range on this projection?* Formula for calculating is:

    Projection +/- 2 (Std error of Y Estimate)

    Answer: Range: 673 - 2 (120.5) to 673 + 2 (120.5) = **[432, 914]**

c. *Build multiple linear regression models for each product with two of its factors. Determine the equation and use the equation to project product demand for a particular value of the factor. Estimate a range.*

Example: Building a multiple linear regression model for ProductXYZ demand versus Factor B and Factor C.

    i. Regression output summary:

Constant	3515.4
Std error of Y estimate	195.0
R^2	0.47
Number of observations	34
X coefficient(s)	99.4 and -2899.5

    ii. *Determine the equation.* Answer: The equation is **ProdXYZ demand = 3515.4 + 99.4 (Factor B) - 2899.5 (Factor C)**

    iii. *Use the equation to project ProdXYZ demand if Factor B = 1.4 and Factor C = 1.1.* Answer: **ProdB demand = 3515.4 + 99.4 (1.4) - 2899.5 (1.1) = 465. 2 = 465**

    iv. *What is the estimated range on this projection?* Formula for calculating is:

        Projection +/- 2 (Std error of Y Estimate)

        Range: 465 - 2 (195)   to   465 + 2 (195) = **[75 , 855]**

d. *Summarize projections with ranges.* *Complete the following table based on your results. (We will use these results step 4 to reconcile ranges and recommend a final forecast.)*

Model Projections and Range: XYZ versus	Lower Limit of Range	Projection	Upper Limit of Range
Factor A	Jan: 432 Feb: Mar:	673	914
Factor B	Jan: 378 Feb: Mar:	762	1,146
Factor C	Jan: 0 Feb: Mar:	280	778
Factor D	Jan: 105 Feb: Mar:	491	877

Factor B and Factor C	Jan: 75	465	855
	Feb:		
	Mar:		

Step 3: Evaluate model performance summaries. You are now approaching the close of another forecasting cycle and you are requested to evaluate the forecasting models for ProdXYZ created during this period.

Question: a. Summary of projections with ranges from exponential smoothing models. *What is a recommended projection and range from the models for ProductXYZ? Summarize in a summary table.* The following results for exponential smoothing (ES) models based only on the historical data were determined for ProdXYZ. *Place your recommend projection and range in the table for each period in the forecast horizon.*

ES Model	MAPE	MAE	RMSE	Lower Limit	Projection	Upper Limit
Simple	174	147	204	203	607	1011
Linear Trend	54	129	188	279	645	1015
Damped Trend	52	125	189	284	641	1021
Recommended						

Question: b. Summary of projections with ranges from regression models. The following results with the multivariable regression models were found for ProdXYZ. *Fill in the missing values.*

Model Projections and Range: XYZ versus	Lower Limit of Range	Projection	Upper Limit of Range
Factor A	Jan: 432	673	914
	Feb:		
	Mar:		
Factor B	Jan: 378	762	1,146
	Feb:		
	Mar:		
Factor C	Jan: 0	280	778
	Feb:		
	Mar:		
Factor D	Jan: 105	491	877
	Feb:		
	Mar:		
Factor B and Factor C	Jan: 75	465	855
	Feb:		
	Mar:		

Step 4: Reconcile Model Projections with Structured Judgment to Arrive at a Final Forecast Number.

Question. *Fill in the following table combining the results of the two major modeling approaches performed for this forecast : univariate exponential smoothing techniques based exclusively on the historical information in ProdXYZ and multivariable regression models based on the inclusion of factor information. Apply informed judgment to arrive at a recommended forecast number.*

Judgment Factors	Projection	Range
	Final Forecast Number	Range
	Jan:	(,)
	Feb:	(,)
	Mar:	(,)

The Forecaster's Checklist

The following checklists can be used as a scorecard to help identify gaps in the forecasting process that will need your attention. It can be scored or color-coded on three levels (Green = YES, Yellow = SOMEWHAT, and Red = NO).

Step 1. Setting down basic facts about past trends and forecasts

--- Are historical tables and plots available?

--- Are base-adjusted data available? (A constant base is needed. For example, have historical revenues been adjusted to today's price. Have data been adjusted for mergers and acquisitions)

--- Are seasonally adjusted data available?

--- Have outliers been explained? (As discussed in the treatment of ARIMA modeling, they may significantly affect the forecasts.)

--- Have cyclical reference dates for business cycles been overlaid?

--- Are percentage changes shown in tables and plots?

--- Have forecast-versus-actual comparisons been made for one or more forecast periods?

Step 2. Determining causes of change in past demand trends

--- Is a trend identified?

--- Is it linear or nonlinear?

--- Are there plots of data and fitted trends?

--- Is the scale of sufficient breadth to see deviations?

--- Have the deviations been explained in writing?

--- Are the explanations of causes specific?

--- Has the source of the explanations been identified?

--- Is the degree of certainty about the explanations noted?

Step 3. Determining causes of differences between previous forecasts and actual data

--- Are differences explained?

--- Are there any patterns to the explanations?

--- Are there basic assumptions that can be reviewed?

Step 4. Determining factors likely to affect future demand

--- Do factors relate to the future?

--- Do factors indicate the direction of impact?

--- Do factors indicate the amount or rate of impact, the timing of the impact, and the duration of the impact on demand?

--- Are there rationale statements for each factor?

--- Are the sources of any rationale statement identified?

Step 5, Making forecasts for future periods

___ Time integration: Are the long-term forecast, short-term forecast, and history all shown on one chart?

___ Item integration: Are the ratios of related items shown, as well as their history through the long-term forecast?

___ Functional integration: Are related forecasts identified and the relationships quantified?

___ Have multiple methods been used for key items and have the results been compared?

___ Has impact on the user of the forecast been considered?

The Forecast Manager's Checklist

Implementation

Step 1. Identify a task or product (What are your needs?)

___ Are models to be used for short-term or long-term forecasts?

___ Are models to be used to solve "what if" questions?

___ Are models to be used to determine elasticities?

___ Are models needed at all?

Step 2. Priorities (Identify these on the basis of your needs)

___ Which quantitative techniques are useful?

___ Should they be implemented?

___ In what order?

___ What is the implementation schedule?

___ How does qualitative analysis fit into total job responsibility?

Step 3. Identification of resources

___ Is management interest and support available?

___ Is money available for computer expenses?

___ Do job responsibilities allow time to meet implementation schedules?

___ Is adequate support available to maintain files?

___ Is economic data available for modeling?

___ Is modeling expertise available for consultation?

Step 4. Database management

___ Who will enter and update data files?

___ Who will identify and correct outliers in data?

___ Will an ongoing program of documentation of outliers be implemented?

___ Will appropriate time series be base-adjusted, if necessary, on an ongoing basis?

___ Will seasonally adjusted data be created and updated periodically?

___ Will data be maintained at the local, area, or company level?

Step 5. Intracompany coordination of modeling techniques

_____   How many individuals in the company will be using quantitative techniques?

___   Can intracompany communications through seminars (and so on) reduce the redundancy and increase the effectiveness of quantitative modeling?

Step 6. Documentation of modeling work for future references

_____   Will modeling work be documented for future reference by others engaged in quantitative analysis?

_____   Will documentation be organized for different aspects of modeling work?

- **Literature:** for publications about work in the modeling field, including trade journals and textbooks on mathematics, statistics, and economics; literature from vendors; modeling studies done by others; and so on

- **Models:** about types of models developed, any changes and reasons for the changes, including information on statistical tests, estimation of parameters, forecast tests, and simulations

- **Data:** about types and sources of data, as well as explanations of adjustments and transformations

- **Forecasting:** containing records on forecasts, forecast errors and monitoring information, and any analyses of forecast errors

- **Software:** about available computer programs

- **Billing and Related Expenses:** about costs related to modeling work

Step 7. Presentation of modeling work for evaluation

___   What kind of feedback on modeling results should be sent to higher levels of management?

___   How should this be done, and how often?

Software Selection

Step 1. Identify needs

___   What level and detail is being forecasted (product, customer, geography, time granularity)?

___   Are the end-user needs well understood?

___   Are models to be used to solve forecasting problems?

___   What are the available sources of data?

___   Are staffing and their staff qualifications adequate?

Step 2. Establish goals and objectives

___   Have you established your goals and objectives for the forecasting process?

___   What are the strengths and weakness of the information systems?

___   Are there requirements for both hardcopy and online forecasting output?

___   Have you set up a planned approach to implementation?

Step 3. Determine functional requirements

___ Have you determined the scope of the system in terms of number of forecasts, size of historical file, system interfacesn and hardware/software performance criteria?

___ What is the environment under which the system is expected to work?

___ What are the time and cost factors related to installing the forecasting system?

___ How are support issues for the system going to be handled?

Step 4. Establish selection criteria

___ What are the program features and capabilities required to support the forecasting process?

___ Have the reporting and export functions been identified?

___ Have performance and maintenance standards been established?

Step 5. Review products

___ What type of systems will be reviewed (mainframe, PC, client-server, intranet, other)?

___ Have you established and prioritized a list of requirements and options?

___ What features, modeling, and reporting capabilities are available?

___ Can you identify pros and cons of each system under review?

___ Are purchase price, implementation/support time, and costs provided by vendor?

Step 6. Evaluate systems

___ Have systems been reviewed based on established criteria?

___ Have you established a short list of potential vendors that fit your needs?

___ Is there a clear set of evaluation standards prepared for the vendor presentations?

___ Can the system be customized, and by whom and at what cost?

___ Are there options to develop a system in-house?

Step 7 Check references

___ Have you checked functionality against your requirements?

___ Can the vendor provide user references in your industry/area?

___ Do vendors provide adequate system documentation?

___ Have you established implementation, training, and support schedules?

___ Can you test the system with live data from your own company?

___ Can you review a vendor's operational system in another company?

Step 8 Acquire the system

___ Have you developed a purchasing recommendation?

___ Can you provide a time, cost, and implementation schedule?

___ Have you established performance criteria with vendor?

___ Are contracts and payment schedules in place?