FORECASTING
An Overview

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The Meaning of Forecasting

THE WIZARD OF ID

IT'S GOING TO SNOW TOMORROW.

WHAT'S THE LONG RANGE FORECAST?

SPRING.

CONTINGENCY PLANNING AS A SUBSTITUTE FOR FORECASTING
Definition of FORECAST

*transitive verb*

1

a: to calculate or predict (some future event or condition) usually as a result of study and analysis of available pertinent data; especially: to predict (weather conditions) on the basis of correlated meteorological observations  
b: to indicate as likely to occur

2

: to serve as a forecast of: PRESAGE <such events may *forecast* peace>

*intransitive verb*

: to calculate the future

— *fore·cast·able adjective*

— *fore·cast·er noun*
My understanding of it

- Forecasting is the prediction of the future of a system using past information.

- Forecasting implies the use of past information. How back into the past depends on the application.

- Prediction on the other hand does not need the past, e.g., the best predictor of tomorrow’s stock price is today’s price.
What do Business Think of Forecasting
KPMG Survey

- The Economist Intelligence Unit and CFO Research conducted a global survey of 544 senior executives. Thirty-five percent of respondents were based in Europe, 30 percent in the Americas and 29 percent in Asia Pacific. The survey reached a very senior audience; over 30 percent of respondents were CFOs. Fifty-nine percent of respondents were from organizations with over US$1 billion dollars in annual revenues and respondents were drawn from a cross-section of industries.

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Although forecasting is traditionally considered a “financial exercise,” leading organizations widely acknowledge that it is at the heart of the performance management process and potentially a significant driver of business value and investor confidence.

All organizations use forecasts to predict and manage their future performance. But although organizations invest significant time and effort in this important task, only one in five currently produce a forecast that is reliable.
The survey results were segmented and analyzed in various ways to shed light on whether top performing organizations take a different approach to forecasting.

In particular, the report analyses responses from organizations with high levels of forecast accuracy (within five percent of actual results over the past three years) compared to those that had a wider margin of error when forecasting over the past three years.

To supplement the survey, the Economist Intelligence Unit conducted a program of interviews with senior executives as well as academics and experts in the field.
Over the last three years,

- Accurate 1%
- Within 5% 22%
  - Avg increase in stock price 46%
- Others
  - Avg increase in stock price 34%
  -
- Avg error 13%
What Improves Forecasting the Most?

- Automation (IT tools)
- Scenario planning/sensitivity analysis
- Rolling forecasts
- Reduction in detail
- Quality of data
Quality of the Data Used

- (40–60%) of the respondents thought financial data was adequate in terms of relevance, timeliness, reliability and insight.

- Only 30–40% of the respondents thought that non-financial data was adequate in terms of relevance, timeliness, reliability and insight.
Technology Lags behind

- 40% of the companies use spreadsheets
- 28% use more accurate tools
- 44% use low technology tools
Where is it housed today?

- Dedicated forecasting team (12%)
- Mainly finance dept. (23%)
- Mixed finance dept. (26%)
- Finance, sales, marketing, supply chain and others (34%)
Forecasting performance

- The survey suggests that companies are much more likely to outperform rather than underperform their predictions, with the average forecast coming out eight percent below actual.
Profile of a good forecaster

- They take forecasting more seriously
  - Accountability, incentives, ongoing performance, earnings guidance
- They look to enhance quality beyond the basics
  - Scenario planning and sensitivity analysis
- They leverage information more effectively
  - External reporting, quality of data, use op. mgrs.
- They work harder at it
  - Use more sophisticated tools, update more often
- They benefit the shareholders
Forecasting and Supply Chains

- Benefits of Collaborative forecasting
  - Lower inventories and capacity buffers
  - Fewer unplanned shipments or production runs
  - Reduced stock-outs
  - Increase customer satisfaction and repeat business
  - Better preparation for sales promotions
  - Better preparation for new product introductions
  - Dynamically respond to market changes

- The Beer Game
  (http://www.masystem.com/o.o.i.s/1365)
Principles of Forecasting


- 139 principles to consider when building a forecast.
Types of Forecasting Methods

- Depending on the type of information used they can be classified into:

  - **Classical forecasting** – using data
    - Smoothing, time series, regression, ARIMA
  - **Judgmental forecasting** – using knowledge
    - Surveys, Delphi method, scenarios, analogy, AHP/NP
  - **Hybrid forecasting** – using both data and knowledge
    - Artificial intelligence, neural nets, data mining
# How to Select a Forecasting Method

## TABLE 2.1  A Guide to Selecting an Appropriate Forecasting Method*

<table>
<thead>
<tr>
<th>Forecasting Method</th>
<th>Data Pattern</th>
<th>Quantity of Historical Data (Number of Observations)</th>
<th>Forecast Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naive</td>
<td>Stationary</td>
<td>1 or 2</td>
<td>Very short</td>
</tr>
<tr>
<td>Moving averages</td>
<td>Stationary</td>
<td>Number equal to the periods in the moving average</td>
<td>Very short</td>
</tr>
<tr>
<td>Exponential smoothing</td>
<td>Stationary</td>
<td>5 to 10</td>
<td>Short</td>
</tr>
<tr>
<td>Simple</td>
<td>Linear trend</td>
<td>10 to 15</td>
<td>Short</td>
</tr>
<tr>
<td>Adaptive response</td>
<td>Trend and seasonality</td>
<td>10 to 15</td>
<td>Short to medium</td>
</tr>
<tr>
<td>Holt's</td>
<td>S-curve</td>
<td>At least 4 or 5 per season</td>
<td>Short to medium</td>
</tr>
<tr>
<td>Winters’</td>
<td></td>
<td>Small, 3 to 10</td>
<td>Medium to long</td>
</tr>
<tr>
<td>Bass model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression-based Trend</td>
<td>Linear and nonlinear trend with or without seasonality</td>
<td>Minimum of 10 with 4 or 5 per season if seasonality is included</td>
<td>Short to medium</td>
</tr>
<tr>
<td>Causal</td>
<td>Can handle nearly all data patterns</td>
<td>Minimum of 10 per independent variable</td>
<td>Short, medium, and long</td>
</tr>
<tr>
<td>Time-series decomposition</td>
<td>Can handle trend, seasonal, and cyclical patterns</td>
<td>Enough to see two peaks and troughs in the cycle</td>
<td>Short, medium, and long</td>
</tr>
<tr>
<td>ARIMA</td>
<td>Stationary or transformed to stationary</td>
<td>Minimum of 50</td>
<td>Short, medium, and long</td>
</tr>
</tbody>
</table>

* The methods presented in this table are the most commonly used techniques. There are many other methods available, most of which are included in the ForecaX™ software that accompanies this text.

Classical Forecasting Models

- Exponential Smoothing
- New Product Forecast
- Regression
- Time Series Decomposition
- Box–Jenkins ARMA/ARIMA
- Transfer Functions
- Generalized ARIMA
- Spectral decomposition
Exponential Smoothing

- **Moving Averages**
  
  $$MA(n) = \frac{X_1 + \cdots + X_n}{n}$$

- **Simple (stationary series)**

  $$F_{t+1} = \alpha X_t + (1-\alpha)F_t$$

- **Double (series with trend)**

  $$F_{t+1} = \alpha X_t + (1-\alpha)(F_t + T_t)$$
  $$T_{t+1} = \beta(F_{t+1} - F_t) + (1-\beta)T_t$$
  $$H_{t+m} = F_{t+1} + mT_{t+1}$$
Exponential Smoothing (cont.)

- Triple (series with trend and seasonality)

\[
W_{t+m} = (F_t + mT_t)S_{t+m-p}
\]
\[
T_t = \beta (F_t - F_{t-1}) + (1 - \beta)T_{t-1}
\]
\[
F_t = \alpha X_t / S_{t-p} + (1 - \alpha) (F_{t-1} + T_{t-1})
\]
\[
S_t = \gamma X_t / F_t + (1 - \gamma) S_{t-p}
\]
Exponential Smoothing (cont.)

- Adaptive Response

\[ F_{t+1} = \alpha_t X_t + (1 - \alpha_t) F_t \]

\[ \alpha_t = \left| \frac{S_t}{A_t} \right| \]

\[ S_t = \beta e_t + (1 - \beta) S_{t-1} \quad \text{(Smoothed error)} \]

\[ A_t = \beta |e_t| + (1 - \beta) A_{t-1} \quad \text{(Absolute smoothed error)} \]

\[ e_t = X_t - F_t \]
An Example
Simple Exponential Smoothing

Time Sequence Plot for JS
Simple exponential smoothing with alpha = 0.0337

(X 1000)

(actual forecast
95.0% limits)
Double Exponential Smoothing

Time Sequence Plot for JS
Holt's linear exp. smoothing with alpha = 0.0688 and beta = 0.084

(X 1000)

actual
forecast
95.0% limits
Triple Exponential Smoothing

Time Sequence Plot for JS
Winter's exp. smoothing with alpha = 0.3893, beta = 0.1892, gamma = 0.2971

(X x 1000)

actual
forecast
95.0% limits
Residual Autocorrelation and Partial Autocorrelation Functions
Residual Test For Randomness

Tests for Randomness of residuals
Data variable: JS
Model: Winter's exp. smoothing with alpha = 0.3892, beta = 0.1893, gamma = 0.2971

1) Runs above and below median
   Median = -0.190066
   Number of runs above and below median = 44
   Expected number of runs = 60.0
   Large sample test statistic z = 2.86606
   P-value = 0.00415633

2) Runs up and down
   Number of runs up and down = 75
   Expected number of runs = 79.0
   Large sample test statistic z = 0.766812
   P-value = 0.443191

3) Box-Pierce Test
   Test based on first 24 autocorrelations
   Large sample test statistic = 86.7623
   P-value = 5.80536E-10
New Product Forecasting

Gompertz Curve

\[ Y_t = Le^{-ae^{-bt}} \]

Logistics Curve

\[ Y_t = \frac{L}{1 + ae^{-bt}} \]
Bass Model

\[
\frac{f(t)}{1 - F(t)} = p + \frac{q}{M} A(t)
\]

\[
F(t) = \frac{1 - e^{-(p+q)t}}{1 + \frac{q}{p} e^{-(p+q)t}}
\]

- \(f(t)\): rate of change of the installed base fraction
- \(F(t)\): installed base fraction
- \(A(t)\): cumulative adopter function
- \(p\): coefficient of innovation
- \(q\): coefficient of imitation
- \(M\): potential market

\[
A(t) = MF(t), \quad t > 0
\]

\[
a(t) = Mf(t)
\]

\[
f(t) = \begin{cases} 
  F(t) & \text{if } t = 1 \\
  F(t) - F(t-1) & \text{if } t > 1 
\end{cases}
\]
Regression

- **Simple regression** (usually to determine the trend of the series)
  
  \[ Y_t = \hat{\beta}_0 + \hat{\beta}_1 X_t + e_t \]
  \[ X_t = \hat{\alpha}_0 + \hat{\alpha}_1 t + e_t^0 \]

- **Multiple Regression**
  
  \[ Y_t = \hat{\beta}_0 + \hat{\beta}_1 X_{1t} + \hat{\beta}_1 X_{2t} + \cdots + \hat{\beta}_1 X_{nt} + e_t \]
  \[ X_{jt} = \hat{\alpha}_{0j} + \hat{\alpha}_{1j} t + e_{jt}^0 \]

- **Seasonality** can be incorporated with dummy variables, but the seasonality length must be known for accuracy.
Time Series Decomposition

- Decompose the series into the trend, seasonality, cyclicality and irregular variations

\[ Y_t = T_t \cdot S_t \cdot C_t \cdot I_t \]

• \( \equiv \times \) or +
Box–Jenkins Methodology

Stationary and non-seasonal series ARIMA(p,d,q)

\[ Y_t = \beta_0 + \sum_{i=1}^{p} \phi_i X_{t-p} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-q} + \varepsilon_t \]

\[ AR(p) = \sum_{i=1}^{p} \phi_i X_{t-p} \text{ (autoregressive component)} \]

\[ MA(q) = \sum_{j=1}^{q} \theta_j \varepsilon_{t-q} \text{ (moving average component)} \]

Notation

(d=0 stationary series)

\[ (1 - B)^d Y_t = \mu + \frac{\varepsilon(B)}{\phi(B)} u_t \quad B^k X_t = X_{t-k} \]

\[ \phi(B) = 1 - \phi_1 B - \ldots - \phi_p B^p \]

\[ \theta(B) = 1 - \theta_1 B - \ldots - \theta_q B^q \]
Box–Jenkins Methodology (cont.)

- Non-stationary, seasonal series
  - ARIMA \((p,d,q)x(P,D,Q)_s\)

\[
(1 - B)^d(1 - B^4)^D Y_t = \mu + \frac{\theta(B)\theta_s(B^4)}{\phi(B)\phi_s(B^4)} \alpha_t
\]
An ARIMA Model

Time Sequence Plot for JS
ARIMA(1,0,1)x(2,2,2)12

(X 1000)

(actual)

forecast

95.0% limits
Residual Analysis

- **Tests for Randomness of residuals**
  - Data variable: JS
  - Model: ARIMA(1,0,1)x(2,2,2)12

  1. Runs above and below median
     - Median = 1.36062
     - Number of runs above and below median = 52
     - Expected number of runs = 55.0
     - Large sample test statistic $z = 0.483389$
     - P-value = 0.628816

  2. Runs up and down
     - Number of runs up and down = 66
     - Expected number of runs = 71.6667
     - Large sample test statistic $z = 1.18915$
     - P-value = 0.234382

  3. Box-Pierce Test
     - Test based on first 24 autocorrelations
     - Large sample test statistic = 14.9128
     - P-value = 0.667944
ACF and PACF
Are ARIMA Model Appropriate in all situations?

Periodogram for JS

(X 1.E7)

Ordinate

frequency
Periodograms

- A periodogram is a graphical analysis technique for examining frequency-domain models of an equi-spaced (the distance between adjacent points is constant) time series. The periodogram is the Fourier transform of the autocorrelation function.

- The periodogram (or spectrum) for a time series is given by:

\[
S(f) = \frac{\Delta}{n} \left\{ \left( \sum_{t=-n}^{n-1} x_t \cos(2\pi ft\Delta) \right)^2 + \left( \sum_{t=-n}^{n-1} x_t \sin(2\pi ft\Delta) \right)^2 \right\}
\]

- where \( f \) is the frequency, \( n \) is the number of observations in the time series, \( \Delta \) is \((n+1)/2\) for \( n \) odd and \((n+2)/2\) for \( n \) even.
A transfer function can be used to filter a predictor time series to form a dynamic regression model.

\[(1 - B)^d(1 - B^s)^D Y_t = \mu + \Psi(B)(1 - B)^d(1 - B^s)^D X_t + \frac{\theta(B)\theta_s(B^s)}{\phi(B)\phi_s(B^s)} a_t\]

- Non-Seasonal

\[\Psi_i(B) = \frac{\omega_i(B)}{\delta_i(B)}(1 - B)^{d_i} B^{k_i}\]

- Seasonal

\[\Psi_i(B) = \frac{\omega_i(B)\omega_s(B^s)}{\delta_i(B)\delta_s(B^s)}(1 - B)^{d_i}(1 - B^s)^{D_i} B^{k_i}\]
Judgmental Forecasting

- Surveys
- Delphi method
- Scenarios
- Analogy
- Analytic Hierarchy/Network Process (AHP/ANP)
A process developed in the 1970’s by T.L. Saaty

Based on paired comparisons to develop relative measurement for single criteria

Composition of the single criteria scales can be:
- Hierarchical (when no dependencies among the criteria exist)
- Network (when dependencies among the criteria are allowed)
Some References on the AHP

Principles of the AHP

- Decomposition (Hierarchy or Network)
- Measurement (pairwise comparisons)
- Synthesis
Forecasting the family size in rural India

From the paper

**Decomposition**

The Hierarchy

- **A1:** culture
- **A2:** economic development
- **A3:** land fragmentation
- **A4:** declining infant mortality
- **A5:** high availability of contraception
- **A6:** scarcity of resources
Measurement

- The Consistent Case

\[
\begin{bmatrix}
w_1 & w_1 & \cdots & w_1 \\
w_1 & w_2 & \cdots & w_n \\
w_2 & w_2 & \cdots & w_2 \\
\vdots & \vdots & \ddots & \vdots \\
w_n & w_n & \cdots & w_n \\
w_1 & w_2 & \cdots & w_n
\end{bmatrix}
= n
\begin{bmatrix}
w_1 \\
w_2 \\
\vdots \\
w_n
\end{bmatrix}
\]
The Inconsistent Case

\[ Aw = nw \quad \text{or} \quad (A-nI)w = 0 \]

- A system of homogeneous linear equations which has a solution if and only if \( \text{Det}(A-nI) = 0 \).

- \( \text{Rank}(A) = 1 \implies \) all but one eigenvalue = 0.

- \( \text{Trace}(A) = n \) and \( \sum \lambda_i = n \Rightarrow \lambda_{\text{max}} = n \)
  (the largest positive eigenvector = n)

  \[ \text{Perturbation} \]

  \[ A'w' = \lambda_{\text{max}}w' \]

  \( (\lambda_{\text{max}} \geq n) \)
Scale for pairwise comparisons

Equal importance
Moderate importance of one over another
Strong or essential importance
Very strong or demonstrated importance
Extreme importance
The Numerical Values

1  Equal importance
3  Moderate importance
5  Strong or essential importance
7  Very strong or demonstrated
9  Extreme importance
2,4,6,8  Intermediate values

Use Reciprocals for Inverse Comparisons
An Experiment

<table>
<thead>
<tr>
<th>Chairs</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>9</td>
</tr>
<tr>
<td>C2</td>
<td>15</td>
</tr>
<tr>
<td>C3</td>
<td>21</td>
</tr>
<tr>
<td>C4</td>
<td>28</td>
</tr>
</tbody>
</table>
# Brightness Example: Subject 1

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>0.62</td>
</tr>
<tr>
<td>C2</td>
<td>1/5</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>0.23</td>
</tr>
<tr>
<td>C3</td>
<td>1/6</td>
<td>1/4</td>
<td>1</td>
<td>4</td>
<td>0.10</td>
</tr>
<tr>
<td>C4</td>
<td>1/7</td>
<td>1/6</td>
<td>1/4</td>
<td>1</td>
<td>0.05</td>
</tr>
</tbody>
</table>
## Brightness Example: Subject 2

<table>
<thead>
<tr>
<th></th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>0.63</td>
</tr>
<tr>
<td>C2</td>
<td>1/4</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>0.22</td>
</tr>
<tr>
<td>C3</td>
<td>1/6</td>
<td>1/3</td>
<td>1</td>
<td>2</td>
<td>0.09</td>
</tr>
<tr>
<td>C4</td>
<td>1/7</td>
<td>1/4</td>
<td>1/2</td>
<td>1</td>
<td>0.06</td>
</tr>
</tbody>
</table>
## Normalized Reciprocal Distance Square

<table>
<thead>
<tr>
<th>Distance</th>
<th>1/Distance^2</th>
<th>Normalized Distance^2</th>
<th>Sub1</th>
<th>Sub2</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>0.01234568</td>
<td>0.6071683</td>
<td>0.62</td>
<td>0.63</td>
</tr>
<tr>
<td>15</td>
<td>0.00444444</td>
<td>0.2185806</td>
<td>0.23</td>
<td>0.22</td>
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<tr>
<td>21</td>
<td>0.00226757</td>
<td>0.1115207</td>
<td>0.10</td>
<td>0.09</td>
</tr>
<tr>
<td>28</td>
<td>0.00127551</td>
<td>0.0627304</td>
<td>0.05</td>
<td>0.06</td>
</tr>
</tbody>
</table>
Comparison of Intangibles

The same procedure as we use for distance can be used to compare things with intangible properties. For example, we could compare apples according to:

- TASTE
- AROMA
- RIPENESS
## Criteria Priorities

<table>
<thead>
<tr>
<th>Contribution to Family Size</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>Relative Priority Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>1</td>
<td>1/7</td>
<td>1/3</td>
<td>1/5</td>
<td>1/9</td>
<td>1/8</td>
<td>.025</td>
</tr>
<tr>
<td>A2</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1/5</td>
<td>1/3</td>
<td>.128</td>
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<tr>
<td>A3</td>
<td>3</td>
<td>1/3</td>
<td>1/5</td>
<td>1/5</td>
<td>1/5</td>
<td>1/5</td>
<td>.053</td>
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<tr>
<td>A4</td>
<td>5</td>
<td>1/23</td>
<td>1</td>
<td>1/5</td>
<td>1/5</td>
<td>1/3</td>
<td>.096</td>
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<tr>
<td>A5</td>
<td>9</td>
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<td>5</td>
<td>5</td>
<td>1</td>
<td>4</td>
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<tr>
<td>A6</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>1/4</td>
<td>1</td>
<td>.231</td>
</tr>
</tbody>
</table>

$\lambda_{\text{max}} = 6.431$

C.I. = 0.086

A1: culture
A2: economic development
A3: land fragmentation
A4: declining infant mortality
A5: high availability of contraception
A6: scarcity of resources
## Priorities of Alternatives

<table>
<thead>
<tr>
<th>Economic Development</th>
<th>Relative Priority Weights</th>
<th>Declining Infant Mortality</th>
<th>Relative Priority Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2</td>
<td>1 2 3</td>
<td>A4</td>
<td>1 1/3 1/2 3</td>
</tr>
<tr>
<td>1</td>
<td>1 2 3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1/2 1 2</td>
<td>2</td>
<td>3 1 1</td>
</tr>
<tr>
<td>3</td>
<td>1/3 1/2 1</td>
<td>3</td>
<td>2 1 1</td>
</tr>
<tr>
<td>$\lambda_{\text{max}} = 3.009$</td>
<td></td>
<td>C.I. = 0.005</td>
<td>$\lambda_{\text{max}} = 3.018$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>C.I. = 0.009</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High Availability of Contraception</th>
<th>Relative Priority Weights</th>
<th>Scarcity of Resources</th>
<th>Relative Priority Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>A5</td>
<td>1 2 3</td>
<td>A6</td>
<td>1 1/4 1/2 3</td>
</tr>
<tr>
<td>1</td>
<td>1 1/3 1/2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3 1 2</td>
<td>2</td>
<td>4 1 1/2</td>
</tr>
<tr>
<td>3</td>
<td>2 1/2 1</td>
<td>3</td>
<td>2 2 1</td>
</tr>
<tr>
<td>$\lambda_{\text{max}} = 3.009$</td>
<td></td>
<td>$\lambda_{\text{max}} = 3.217$</td>
<td></td>
</tr>
<tr>
<td>C.I. = 0.005</td>
<td></td>
<td>C.I. = 0.109</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scarcity of Resources</th>
<th>Relative Priority Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>A6</td>
<td>1 1/4 1/2 3</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4 1 1/2</td>
</tr>
<tr>
<td>3</td>
<td>2 2 1</td>
</tr>
<tr>
<td>$\lambda_{\text{max}} = 3.217$</td>
<td></td>
</tr>
<tr>
<td>C.I. = 0.109</td>
<td></td>
</tr>
</tbody>
</table>
Synthesized Priorities

The factors at successively lower level of the hierarchy can now be weighted by those in the level immediately above which influence them. We obtain the following weighted priorities for the number of children.

\[
\begin{align*}
.540 & \quad .169 & \quad .163 & \quad .119 & \quad .213 \\
(\cdot139) & \quad .297 + (\cdot104) & \quad .443 + (\cdot507) & \quad .540 + (\cdot251) & \quad .376 = \quad .455 \\
.163 & \quad .387 & \quad .297 & \quad .474 & \quad .333
\end{align*}
\]

The final weighted vector is given by:

<table>
<thead>
<tr>
<th>Number of children</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority weights</td>
<td>.213</td>
<td>.455</td>
<td>.333</td>
</tr>
</tbody>
</table>
Finally we compute the expected number of children for a family in rural India as our expected value:

\[(.213 \times 1) + (.455 \times 2) + (.333 \times 3) = 2.122.\]
A large number of thriving children is still highly desired by the majority of rural Indian families. One of the most common explanations of high fertility is the alleged preference of Indian parents for male children. Sons are a man's best support when he needs help most, during harvests or in confrontations in village fights and feuds. It is also believed that sons can improve the parents destiny in the afterworld by performing certain rites after the parents' deaths.
Our purpose now is to use the foregoing factors as determinants of the average number of children in a family in rural India:

- **Level I:** Optimal family size
- **Level II:**
  - A1 Culture
  - A2 Economic factors
  - A3 Demographic factors
  - A4 Availability of contraceptives
Subcriteria

Level III:
- B1 Religion
- **B2 Women's status**
- B3 Manlihood
- B4 Cost of child-rearing
- **B5 Old age security**
- **B6 Labor**
- B7 Economic improvement
- **B8 Prestige and strength**
- B9 Short life expectancy
- **B10 High infant mortality**
- B11 High level of availability of contraception
- B12 Medium level of availability of contraception
- B13 Low level of availability of contraception
Most Likely Number of Children

<table>
<thead>
<tr>
<th>Number of children</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weights</td>
<td>.073</td>
<td>.028</td>
<td>.039</td>
<td>.061</td>
<td>.092</td>
<td>.051</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.117</td>
<td>.057</td>
<td>.088</td>
<td>.102</td>
<td>.147</td>
<td>.099</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.298</td>
<td>.141</td>
<td>.184</td>
<td>.190</td>
<td>.269</td>
<td>.205</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(.243)</td>
<td>.303 + (.370)</td>
<td>.269 + (.183)</td>
<td>.282 + (.097)</td>
<td>.301 + (.107)</td>
<td>.224 =</td>
<td>.279</td>
</tr>
<tr>
<td></td>
<td>.096</td>
<td>.259</td>
<td>.204</td>
<td>.181</td>
<td>.128</td>
<td>.188</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.050</td>
<td>.161</td>
<td>.130</td>
<td>.110</td>
<td>.085</td>
<td>.116</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.033</td>
<td>.086</td>
<td>.037</td>
<td>.054</td>
<td>.054</td>
<td>.064</td>
<td></td>
</tr>
</tbody>
</table>

Thus, the relative priority weights of the number of children are as follows:

Number of children  4   5   6   7   8   9   10

Weights            | .051 | .099 | .205 | .279 | .188 | .116 | .064 |
The weights obtained for each number of children under each factor at level III are finally multiplied and summed. We have

\[(4 \times 0.051) + (5 \times 0.099) + (6 \times 0.205) + (7 \times 0.279) + (8 \times 0.188) + (9 \times 0.116) + (10 \times 0.064) = 6.494.\]
It has been reported by many that the mean number of children a woman has after she completes her reproductive cycle is 6.4. (Driver 1963: 86, 101-102; Ridker 1969: 280-281; Mandelbaum 1974: 15).
Stats (March 2001)

- **Total Fertility Rate** (average number of children born to a woman during her lifetime) **3.30**
  - Only nine states or union territories in the country have a TFR less than or equal to the desired **2.1**:
  - Eleven have a total fertility rate of more than **2.1** but less than **3.0**.
  - At least **12** have a total fertility rate of **3.0** or over.

**Eighteen per cent of births** are to teenage women aged between **15 and 19**

**Forty-nine per cent of women** give birth for the first time by age **20**.

**The average age at first marriage** (or informal union) is **20**.

**Forty-three per cent of married women** are using modern methods of contraception.

**Females in secondary school/100 males:** **65**
Forecasting the Resurgence of the U.S. Economy in 2010: An Expert Judgment Approach

From a paper of the same title by Andrew R. Blair, Gershon Mandelker, Thomas L. Saaty and Rozann Whitaker (unpublished work)
The Forecast

- The recovery is projected to occur 19.5897 months after December 2008 or sometime around late July or early August 2010; that is to say, toward the middle of the third quarter of 2010.

Table 1. Computing the expected number of months until the turnaround of the economy

<table>
<thead>
<tr>
<th>Alternative Time Periods (span of time being considered)</th>
<th>Priorities (Normals)</th>
<th>Midpoint of time period measured in months</th>
<th>Priority × Midpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Zero to six months (0 to 6)</td>
<td>0.0968</td>
<td>3</td>
<td>0.2904</td>
</tr>
<tr>
<td>2 Six to twelve months (6 to 12)</td>
<td>0.1997</td>
<td>9</td>
<td>1.7973</td>
</tr>
<tr>
<td>3 Twelve to twenty-four months (12 to 24)</td>
<td>0.3001</td>
<td>18</td>
<td>5.4018</td>
</tr>
<tr>
<td>4 Twenty-four to thirty-six months (24 to 36)</td>
<td>0.4034</td>
<td>30</td>
<td>12.1002</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>19.5897</strong></td>
<td><strong>19.5897</strong></td>
<td></td>
</tr>
</tbody>
</table>
Steps of Forecasting

- **Make Objectives Clear**: Communication of the role of forecasts in the decision process will help ensure management confidence in forecasts.

- **Determine What to Forecast**: Good communication between management and the forecast staff is important in making certain that the appropriate variables are being forecast.

- **Establish Time Dimensions**: Forecast horizon and urgency are important factors in determining an appropriate forecasting method.

- **Database Considerations**: Data limitations may constrain the set of possible forecasting methods. Accordingly, database management of internal data is a critical function in the forecasting process.

- **Model Selection**: Model selection depends foremost of the attributes of the data, e.g., trend, season, and periodicity.

- **Model Evaluation**: Since the ultimate goal is to provide the best forecasts, the emphasis should be on out-of-sample (holdout period) accuracy, not in sample (historic period) fit as measured by RMSE.

- **Forecast Preparation**: Never give one number. Use different methods to generate a range of forecasts and address the issue of information diversity by combining forecasting methods to improve accuracy.