The Actuarial Profession
making financial sense of the future

**GIRO Conference and Exhibition 2012**

## Expert Judgment Hot Topic

**Don Mango, Expert, Guy Carpenter New York**

I want you…to participate!



## Expert Judgment – Meaningful Questions

- What constitutes an expert?
- How can we resolve conflicts among equals?
- Can we find comparables and benchmarks?
- Does human intervention help?
- What is the GOAL of all this capital modeling?

## Expert Judgment – Agenda

- Review of external research – way outside insurance
- Including a warning from the lost tribe of actuaries in water resource management
- Dense material in the PPT -- key points highlighted in **bold blue**





## Expert Judgment
*Takeaway of Takeaways*

- **Well-structured judgmental process can consistently outperform a statistical model-based extrapolation**
- **Lost tribes:**
  - **Weather forecasters**
  - **Water resource management**
- **Gateways for incorporating expert judgment**
- **Judgments become less reliable as the amount of information available increases**
- **Limit the amount of information used**
- **Use a small number of very important cues**
- **We should care about orchards**

## Expert Judgment – External Research

1. **"Interaction of Judgemental and Statistical Forecasting Methods: Issues and Analysis"**
   Derek Bunn and George Wright, *Management Science*, Vol. 37, No. 5, May 1991
2. **"Improving Reliability of Judgmental Forecasts"**
   Thomas R. Stewart, in J.S. Armstrong (Ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners,* Kluwer Academic Publishers
3. **"Consequences and Responsibilities in Drought Forecasting: The Case of Yakima, 1977"**
   Michael H. Glantz, *Water Resources Research,* Vol. 18, No. 1, February 1982





## Bunn and Wright – *Seminal Paper*

- All serious forecasts require the exercise of some judgment
  - Extent to which judgment should be used in certain situations, and
  - How that process should be structured
- **Well-structured judgmental process can consistently outperform a statistical model-based extrapolation**
- Example:
  Loan review committees > Single Officer > Model
  - **Committee reduced # of loan errors**

## Bunn and Wright

- Judgmental probability forecasting
- Example: weather forecasting
  - **Large amount of information available, including output from statistical techniques**
  - **Receive detailed feedback and have opportunity to gain experience by forecasting under wide range of conditions**
  - **Considerable practice in quantifying their internal state of uncertainty**





## Bunn and Wright

- Learning judgmental forecasting as a skill
- Structured interaction of judgment and statistical forecasting methods
- Explicit structure for incorporating judgment – “model” of judgmental influence
- **Gateways for the incorporation of judgment**

## Bunn and Wright
*Gateways for Incorporating Judgment*

- Variable selection: experts differentiate more by **the variables to which they refer**
- Model specification:
  - Towards structured models for more transparent understanding of the models → promoting greater judgmental interaction
  - Example: Box-Jenkins ARIMA model
    - Judgmental tasks difficult for the expert and confusing for the layman
    - Box-Jenkins aims for more reliable automation, **removing judgment**





## Bunn and Wright
*Gateways for Incorporating Judgment*

- Parameter Estimation
  - Statistical decision theory in 1960's
  - **Enthusiasm for encoding subjective belief via Bayesian priors**
  - Implementation waiting on development of **effective elicitation procedures**
  - Relying upon heuristic default values

## Bunn and Wright
*Gateways for Incorporating Judgment*

- Data Analysis
  - Primarily a judgmental aspect of model-building
  - **How far back to go in a time series involves a judgment of structural stability**
  - How much to correct data, ex post, for special events





## Stewart
*"Improving Reliability of Judgmental Forecasts"*

- **Brunswik's Lens Model Equation**
- Forecast accuracy is a function of
  - [ Environmental uncertainty ]
  - [ Match between Forecast and Environment ]
  - [ Forecast reliability]
- Reliability of judgmental forecasts is a function of
  - Reliability of **information acquisition**
  - Reliability of **information processing**

## Stewart
*Reasons for Lack of Reliability of Judgment*

- Failure of cognitive control
- **Overloading working memory**
- Recursive weight estimation during learning
- Learning correlations rather than learning functions
- Reproducing noise
- **Deterministic rule switching**





## Stewart

- **Judgments become less reliable as the amount of information available increases**
  - Repeated research shows **forecasters performed worse when presented with larger time series**
  - While more information could serve to improve the forecaster's understanding of the environment at the time of the forecast, it also increases the complexity of the forecasting task and may impose a cognitive burden that exceeds human information processing capacity
- Judges are not able to make proper use of large numbers of cues
- People use only a subset of available information

## Stewart
*Reliability of Information Acquisition*

- Extent to which forecaster can reliably make use of available information and displays to infer subjective cues from the objective cues
  - Primary cues = observable
  - Secondary cues = extracted or inferred from combinations of primary cues
- Weather forecasting and medical diagnosis require **interpretation of images or recognition of complex patterns in data that are distributed over time or space**





## Stewart
*Intuition versus Analysis*

- Analysis = step-by-step, conscious, logically defensible
- Intuition = answer, solution or idea without a process
- Judgment is quasi-rational, elements of both analysis and intuition
  - Intuition and analysis form a continuum
- Different error profiles
  - Intuition is robust but imprecise
  - Analysis is precise but subject to large error (when errors are made)

## Stewart
*Reliability of Information Processing*

- **Limit the amount of information used**
- **Use a small number of very important cues**
- **Use mechanical methods to process information**
- **Have experts judge the cues, where necessary, and then use models to process the information**
- **Humans are better at information acquisition, while machines are better at information processing**



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## Glantz
*Why We Should Care About Orchards*

- Capital is a shared asset – like water
- Water analysis is actuarial
- Loads of forecasts compound to produce estimates of the capital (water)
- **Lines of business are perennials** – franchise (IP) investments that cannot survive droughts



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## Glantz
*Why We Should Care About Orchards*

- Yakima River Valley, Washington State
- **Arid agricultural region** heavily dependent on irrigation
  - Large system of reservoirs
- Forecast water levels function of rainfall, snowpack, and streamflow
  - Complex forecasting exercise
- Multiple competing uses for the water: irrigation, power, fisheries



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## Glantz
*Why We Should Care About Orchards*

- 1976: widespread drought in US, especially Western states
- Feb 1977: National Oceanographic and Atmospheric Association (NOAA) issues assessment :
  - Water supply outlook is poor
  - Record low snowpack
  - Rivers likely to yield all-time lows in spring
- Washington State committee to deal with impact of impending drought
  - *"Clearly, **viewed strictly from an actuarial basis**, the Pacific Northwest should plan for much drier conditions than has been experienced in the last two decades."*



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## Glantz
*Why We Should Care About Orchards*

- Complex set of water rights along the Yakima river
  - Riparian = any land on the river has rights
  - **Prior Appropriation** = first in time, first in rights
    - Older regions have non-proratable rights
    - Newer regions only get water once those rights are met
- Source of the subsequent problems



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## Glantz
*Why We Should Care About Orchards*

- Rainfall for Oct 1976 – Jan 1977 was lowest on record
- Snowpack was fifth lowest on record
- Bureau of Reclamation review of water supply estimates:
  - *The outlook was for the **drought condition to continue** during the remaining months preceding the 1977 irrigation season when precipitation normally occurs*
- Broader context:
  - 1976 California drought
  - Broader forecasts for Western US drought conditions



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## Glantz
*Total Water Supply Available (TWSA) Estimate*

- Feb 1977 announcement
  - Give users a sense of availability for April – October season
- **Composed of three elements:**
  - **Natural flow**
  - **Storage**
  - **Other sources (return flow)**
- Estimate updated monthly as new information becomes available





## Glantz
*Total Water Supply Available (TWSA) Estimate*

- Forecast: 1977 TWSA = **half the long term average**
- Allocation formula applied:
  - Senior (older) districts would get nearly 100% of their normal allocation
  - **Junior districts as little as 6%**
- Clear understanding that **perennial plants and trees would be destroyed**
  - i.e., fruit orchards
  - Loss of production for up to eight years

## Glantz
*Total Water Supply Available (TWSA) Estimate*

- Junior district perennial farmers considered:
  - Digging wells (who controls the permits?)
  - Leasing water rights from annual crop farmers
    - At 2 to 3 times the normal rate
    - Created animosity among farmers that continues to this day
  - Large-scale diversion projects
    - Including dead storage water – water below the dam's outlet level
  - Crop transplanting
  - Weather modification





## Glantz
*Updating the TWSA Estimate Spring 1977*

- April: junior districts allotment increased to 13%
- Mid-May: allocations to increase anywhere from 11% to 380% higher than latest Bureau projections
  - Admitted that previous projections were **'overly conservative'** and 'a lot of farmers probably **went into debt** to drill new wells or simply decided not to plant certain crops based on the earlier water estimates'
- End of season allocations = 70% of normal, not the 50% originally projected

## Glantz
*Fallout from Updated TWSA Estimate*

- Cover story: *rainfall ended up being higher than projected*
- But the damage had already been done
- Angry farmers demanded an inquiry
- Senator Jackson (Washington State): '***Bureau's revised estimates were not based on recent rainfall, but on a re-examination of present [existing] supplies***'
- Lawsuits to recover damages (lost crops, well drilling costs, leasing costs, etc.)





## Glantz
*TWSA Estimate Post-Mortem*

- Forecast = fn( natural runoff, water available in storage, return flow)
  - Return flow = diverted water that returns to the stream and is available for downstream users
- Bureau made an error in their modeling efforts, by understating 'return flow'
  - Coming from a flood control mindset
  - Erroneous for TWSA estimate
  - **Difference between disaster and workable allocations**

## Glantz
*TWSA Estimate Post-Mortem*

- Junior districts **pay the maintenance for reservoirs** specifically built for their use
  - Senior districts got access to this water
- Three government agencies issues forecasts for their users
  - Bureau initial = 1.07M Acre-Feet
  - Soil Conservation Service = 640K A-F
  - National Weather Service = 589K A-F
  - Bureau reacted by ***lowering their estimate***





## Glantz
*TWSA Estimate Post-Mortem*

- Bureau forecasters also deliberately adopted a conservative forecast because
  1. Low precipitation since 1976
  2. Likelihood the drought would continue into the foreseeable future
  3. **'Fear of promising more water than could be delivered'**

## Glantz
*TWSA Estimate Post-Mortem*

- Based largely on subjective criteria, Bureau adopted an ultra-conservative natural runoff forecast – essentially the worst case version of NWS forecast (the experts)
- Bureau **lost "a whole generation of credibility…they had established with the irrigators since 1945"**
- Further exacerbated when in **1979 the opposite happened**: closed a dam for repairs in the spring based on a forecast that other water would be plentiful – it was not and damages resulted again





## Glantz
*TWSA Estimate Post-Mortem*

Special task force found three problems in 1977 and 1979

1. Technical problems in forecasting
2. Operations different from normal years
3. Communications at all levels which at times left the water users and public frustrated and uninformed

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# End of Prepared Remarks

## Thank you