# Recognition of Uncertainty and Complexity

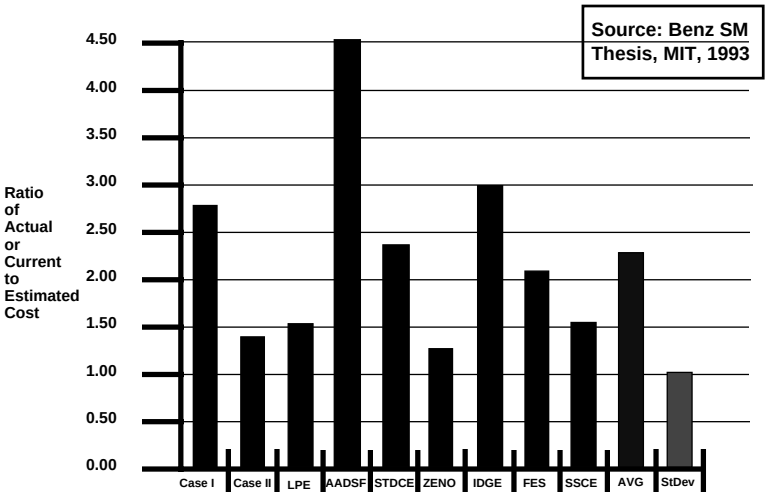
- **Uncertainty: Wide Range of Futures**
  - **The forecast is "always wrong“**
    - **“risks” that is, the bad things that can happen**
    - **“opportunities” that is, the other side of the distribution, the good things that can happen**



# Recognition of Uncertainty

- **The usual error**
  - **Search for correct forecast**
- **However: the forecast is "always wrong"**
  - **What actually happens is quite far, in practically every case, from what is forecast**
  - **Examples: costs, demands, revenues and production**
- **Need to start with a distribution of possible outcomes to any choice or decision**

# Cost Growth Experience
# NASA Microgravity Projects



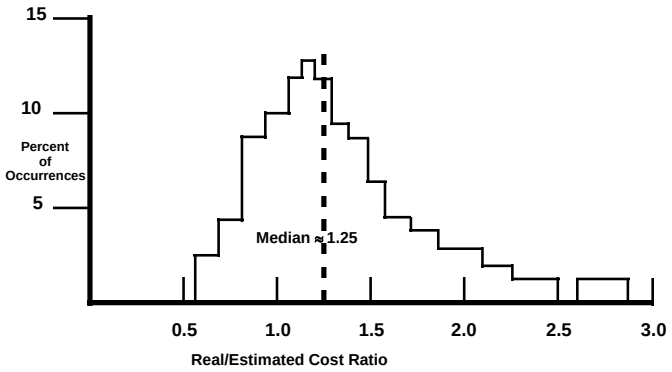



# Let's look at simplest case

- **Simplest possible technology: asphalt paving of existing runways – long flat surfaces with everything visible**
- **A really simple issue: Cost – straightforward routine operation**
- **Sample of about 59 cases from the files of airports in the United States, comparing estimated cost with actual cost, adjusted for inflation according to construction price index.**
- **RESULTS OFF IN RANGE OF A FACTOR OF 2!**

# Ratio of Real Costs

**Expressed in constant dollars, to estimated costs for routine airport projects**




**Source: de Neufville and Odoni, "Airport Systems Planning" McGraw-Hill, 2003**



# Cost of asphalt rising

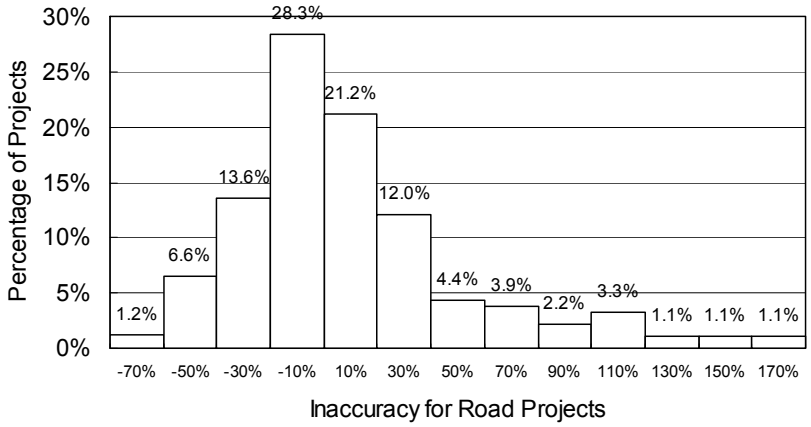
## Local road repairs are likely to lag

By Kay Lazar, Globe Correspondent June 8, 2006
http://www.boston.com/news/local/articles/2006/06/08/cost_of_asphalt_rising/

The soaring cost of petroleum -- a primary ingredient of asphalt -- has forced many communities to shoulder a 50 percent increase in costs as crews head out to repave roads this summer. Asphalt sticker shock is creating heartburn for legions of highway chiefs, prompting many to significantly curtail the number of roads they intend to repair this season.

And the going may get even tougher. Two major asphalt suppliers for the region are warning of another 50 percent increase by Thanksgiving -- in addition to potential shortages

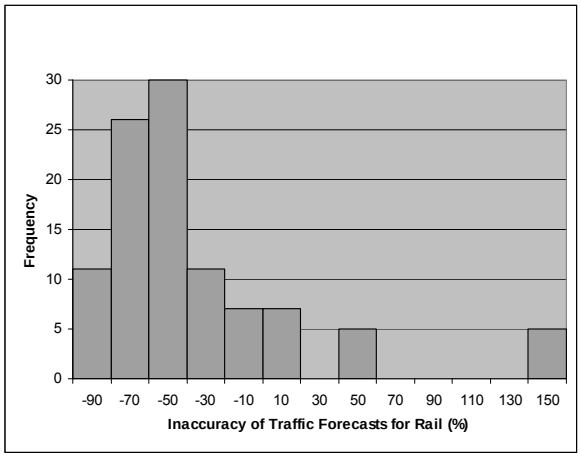
# Forecast vs. actual costs of road projects




**Source: Flyvbjerg et al (2005**)



# Forecast vs. actual costs of rail projects




**Source: Flyvbjerg et al (2005**)

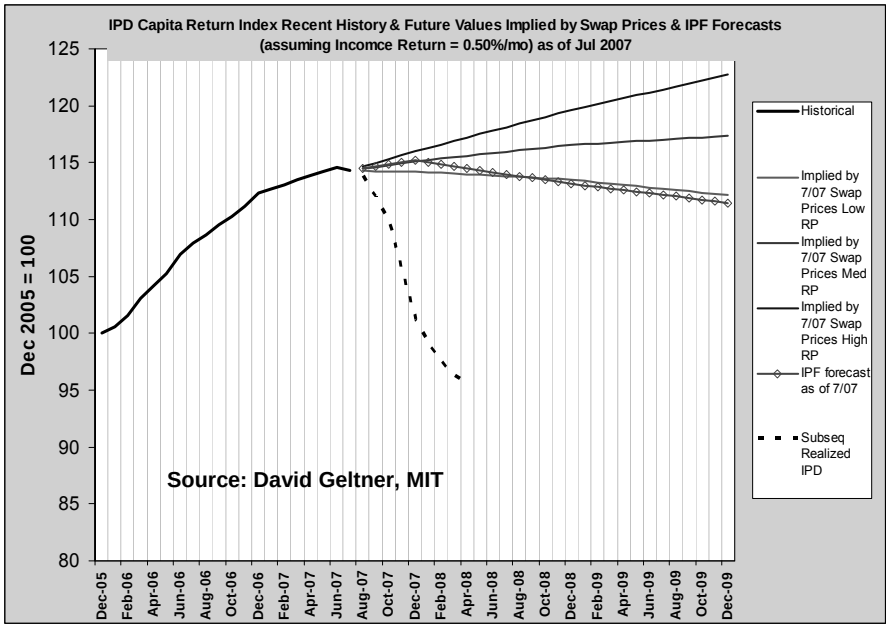
# Real Estate Forecasts

## Courtesy Prof Geltner, MIT Center for Real Estate

- **The next slides show forecasts for commercial property prices for the UK, the IPD Index**
- **Note: this price should be relatively easy to predict**
  - **Real estate fairly stable – not created rapidly and people do not move easily**
  - **Also, fairly transparent how it functions**
  - **In short, not "rocket science"**
- **Note also that many experts make the markets that are the basis for these forecasts**
- **20% drop (July 07 to April 08) is the steepest fall ever– Yet nobody saw it coming, apparently**

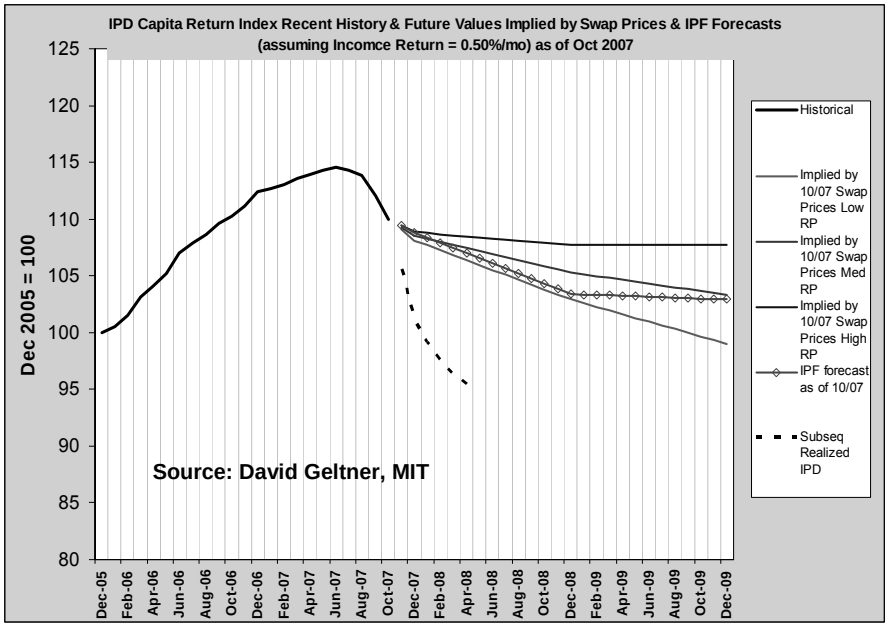


IPD Capital Return Index: July 2007



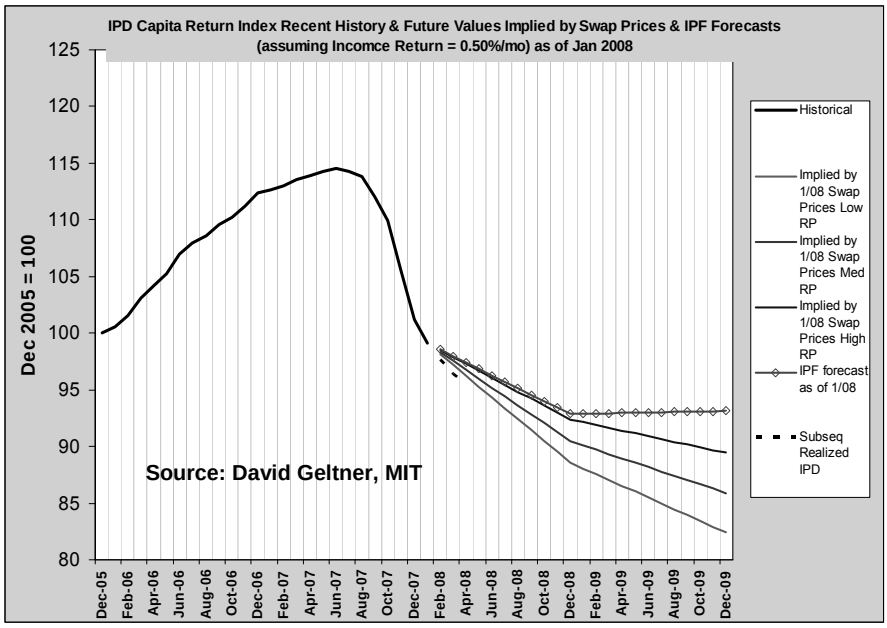

Risk premium (RP) assumptions (p/a): Low = 0%, Med = 2%, High = 4%. Geltner **MIT/**CRE © 2008

## IPD Capital Return Index: October 2007



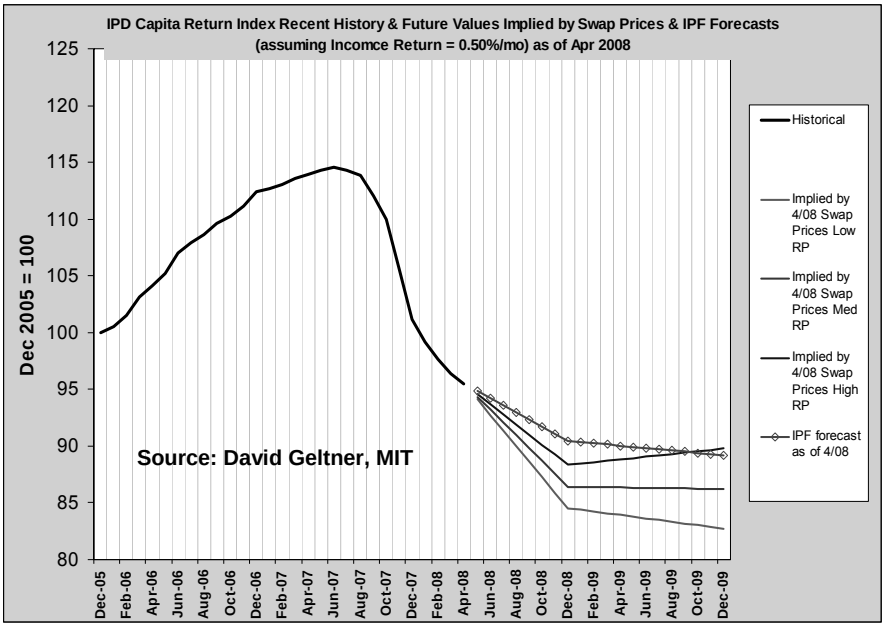

Risk premium (RP) assumptions (p/a): Low = 0%, Med = 2%, High = 4%. Geltner **MIT**/CRE © 2008

## IPD Capital Return Index: January 2008




Risk premium (RP) assumptions (p/a): Low = 0%, Med = 2%, High = 4%. Geltner **MIT**/CRE © 2008

IPD Capital Return Index: April 2008




Risk premium (RP) assumptions (p/a): Low = 0%, Med = 2%, High = 4%. Geltner **MIT**/CRE © 2008

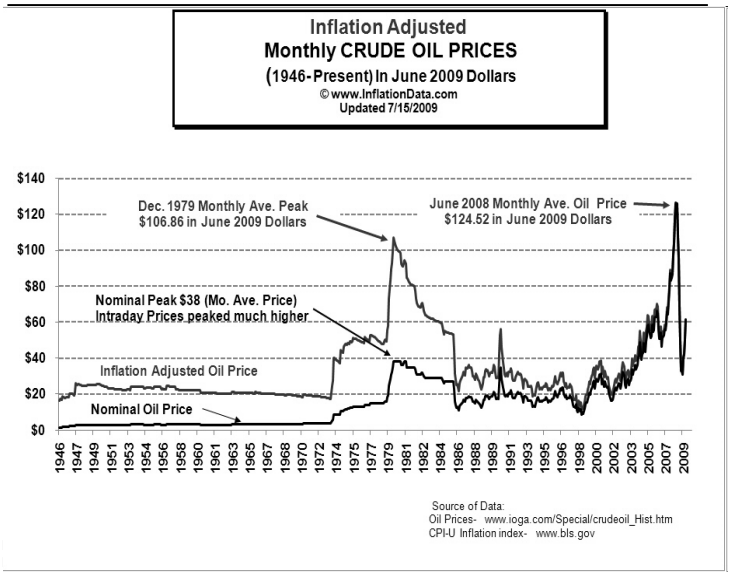
# More Complicated Cases

- **Major commodities**
  - **Copper, and then Oil**
  - **Many Hidden factors – deposits deep under ground (or water); quantities or qualities not known until deposit exploited**
- **Water Usage in Boston**
  - **Involves personal preferences, these cannot be measured directly in "real world", difficult to estimate correctly**

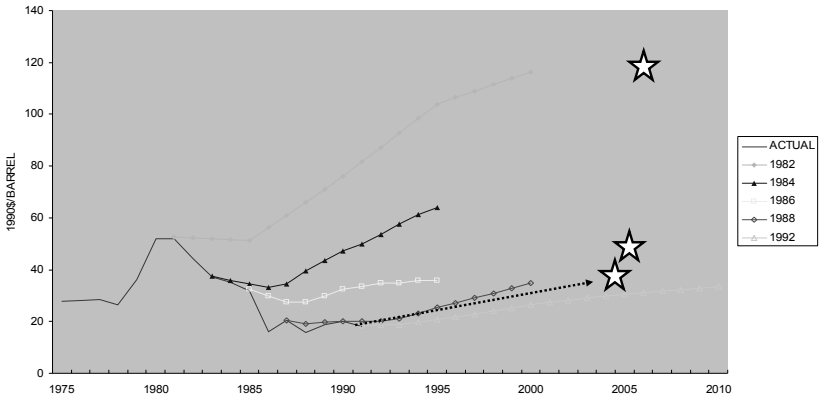
# Copper Prices


**Source: http://www.findata.co.nz/Markets/StockQuote/COMEX/HG.htm**

# History of Oil Prices



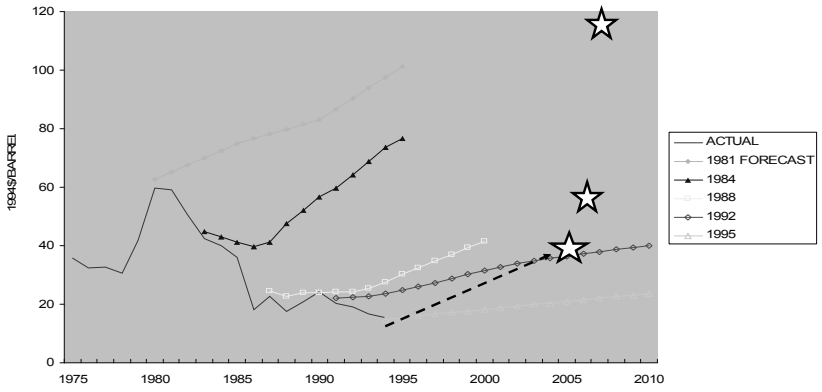
# DOE Oil Price Forecasts




**Source: M. Lynch, MIT**

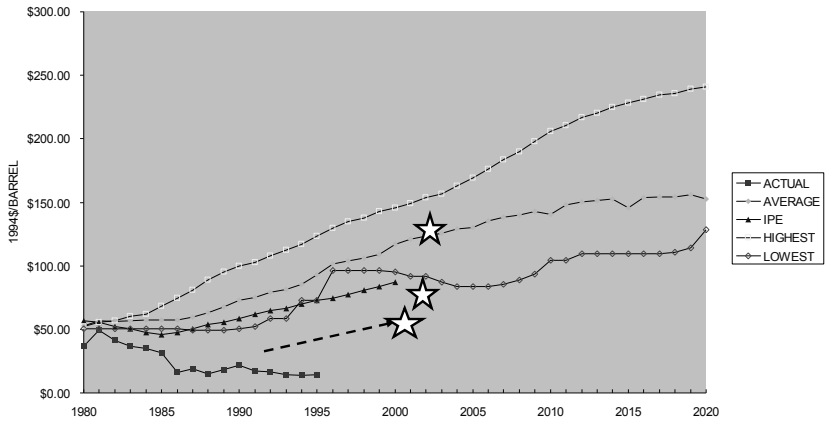


# DOE Oil Price Forecasts




**Source: M. Lynch, MIT**

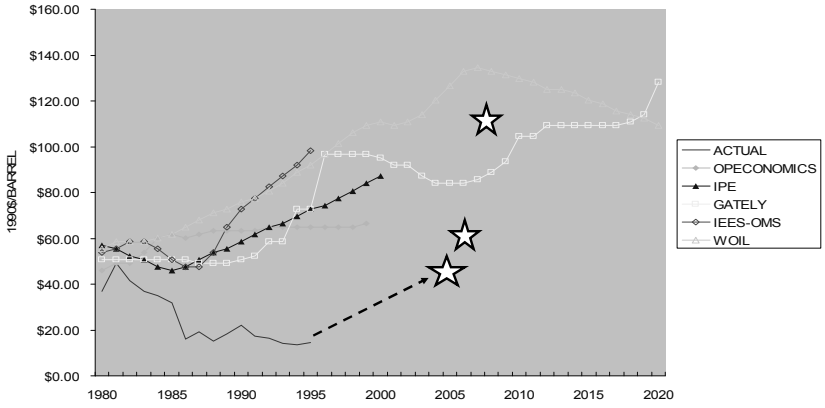
# EMF6 Oil Price Forecasts




**Source: M. Lynch, MIT**

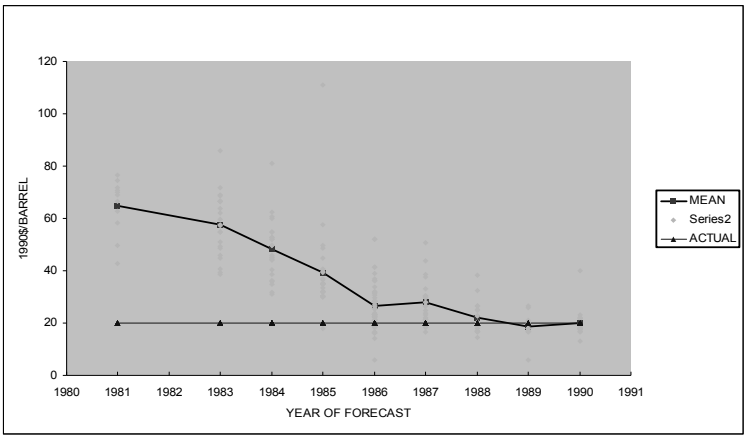


# EMF6 Oil Price Forecasts (Low)




**Source: M. Lynch, MIT**

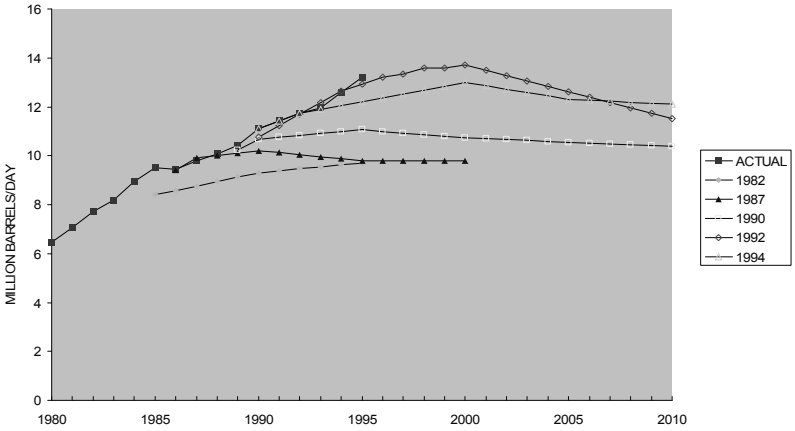
# Forecasts of 1990 Price of Oil




**Source: M. Lynch, MIT -- IEW Survey**

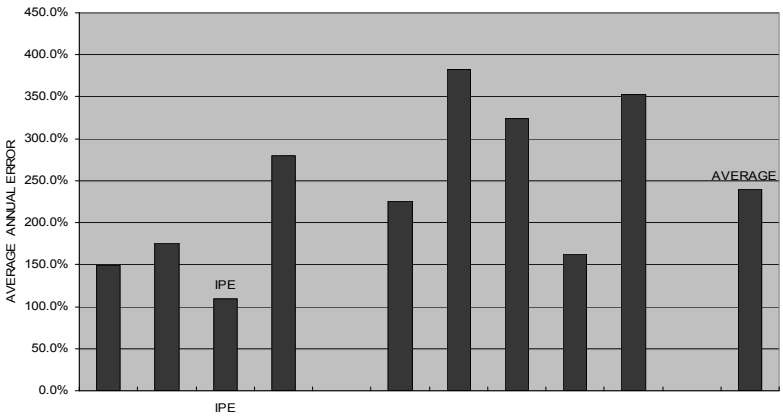


# DOE Forecasts
# Non-OPEC LDC Production




**Source: M. Lynch, MIT**

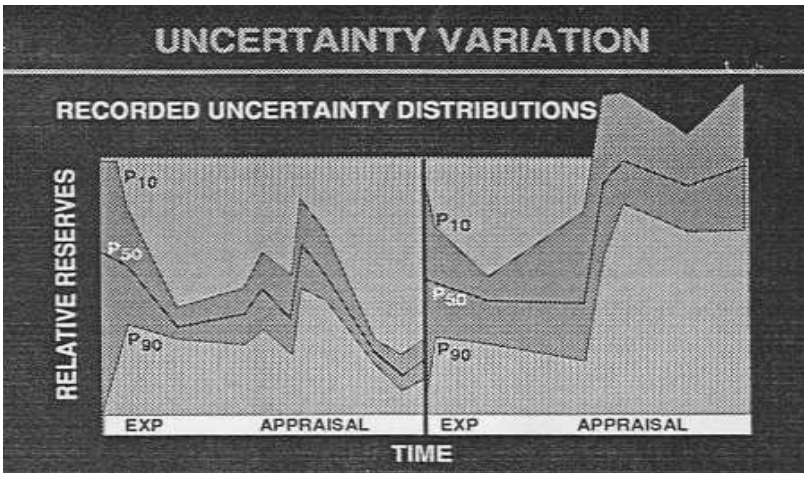
# Error in OPEC Revenue Forecast EMF6 1980 - 1995




**Source: M. Lynch, MIT**

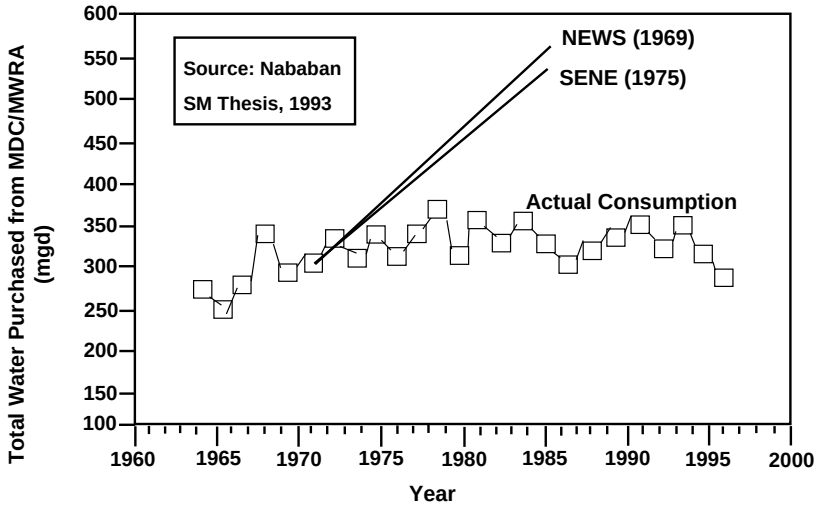


# Variation in estimates of oil commercially extractable from fields



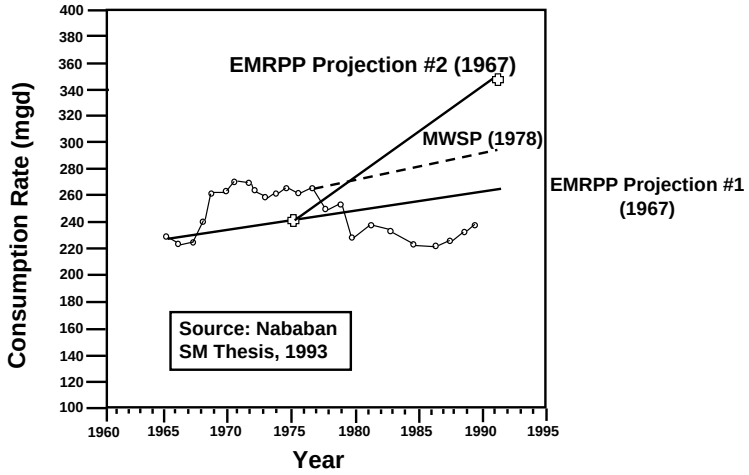

**Source: Lin ( 2009) from BP sources**

# Forecasts of Water Use in Boston (MWRA Members)






# Forecasts of Water Use in Boston (MWRA Service Area)



## Why we can't predict well: Surprises!

- **Surprises**
  - **All forecasts are extensions of past**
  - **Past trends always interrupted by surprises, by discontinuities:**
    - **Major political changes**
    - **Economic booms and recessions**
    - **New industrial alliances or cartels**
- **The exact details of these surprises cannot be anticipated, but it is sure surprises will exist!**
- **Example: MWRA Quincy pellet plant**
  - **When the s…. Hit the fan!**



## Why we can't predict well: Ambiguity

- **Ambiguity**
  - **Analysis can look at many ranges of historical record**
  - **Moreover, from any set of historical data many extrapolations possible**
    - **Different explanations (independent variables*)***
    - **Different forms of explanations (equations)**
    - **Different number of periods examined**
  - **Many of these extrapolations will be "good" to the extent that they satisfy usual statistical tests**
  - **Yet these extrapolations will give quite different forecasts!**
  - **Example: Forecasts of Airport Traffic for Los Angeles**

## Consequences of Uncertainty

- **The Resulting Problem: Wrong Plans**
  - **Wrong Size of Plant, of Facility**
    - **Boston Water Treatment Plant**
  - **Wrong type of Facility**
    - **Although "forecast" may be "reached"…**
    - **Components that make up the forecast generally not as anticipated, thus requiring**
    - **Quite different facilities or operations than anticipated**
    - **Baltimore Airport Buildings – US Airways / Southwest**



## Rear View Mirror Analogy

- **Relying on forecasts is like driving by looking in a rearview mirror --**
- **Satisfactory for a while, so long as trends continue, but soon one runs off the road.**

# Take-aways from presentation

- **The forecast is "always wrong"**
  - ♦ **And there is no escape from this:**
  - ♦ **… Analysis based on too many assumptions**
  - ♦ **… and there are inevitable surprises**