

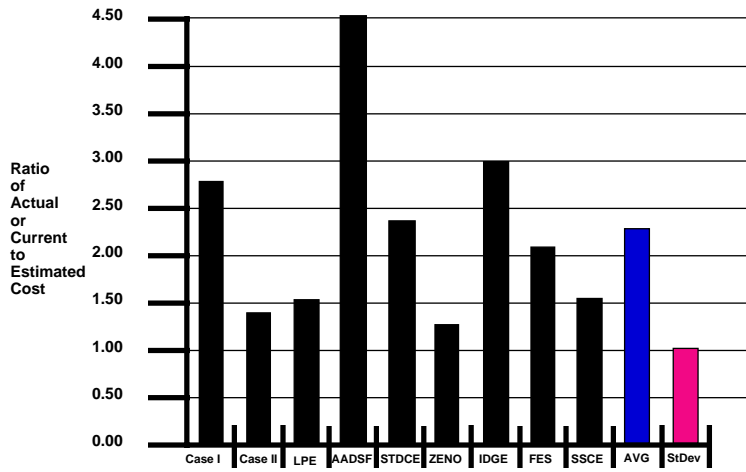
Recognition of Uncertainty and Complexity

- **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
- **Complexity: Wide Range of Choices**
 - Number of Choices is Enormous
 - ♦ "Pure" solutions only 1 or 2% of possibilities
 - ♦ Most possibilities are "hybrid", that combine elements of "pure" solutions
 - ♦ "Hybrid" choices provide most flexibility

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



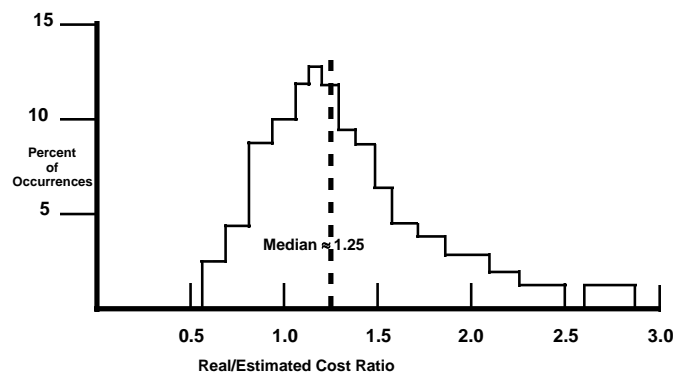
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Ratio of Real Costs

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



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Cost of asphalt rising Local road repairs are likely to lag

By Kay Lazar, Globe Correspondent

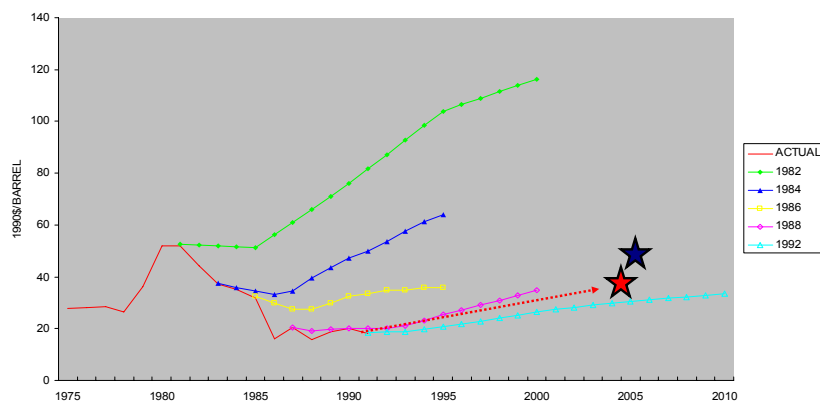
June 8, 2006

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.

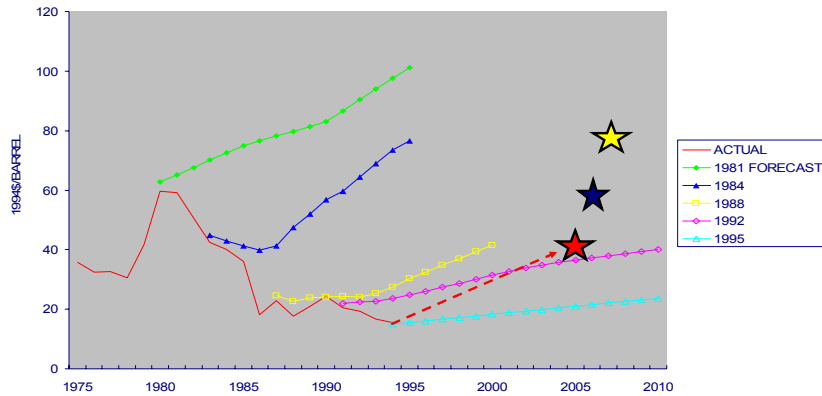
And the going may get even tougher. Two major asphalt suppliers for the region are warning of another 50 percent increase by Thanksgiving -- in addition to potential shortages

DOE Oil Price Forecasts



Source: M. Lynch, MIT

DOE Oil Price Forecasts



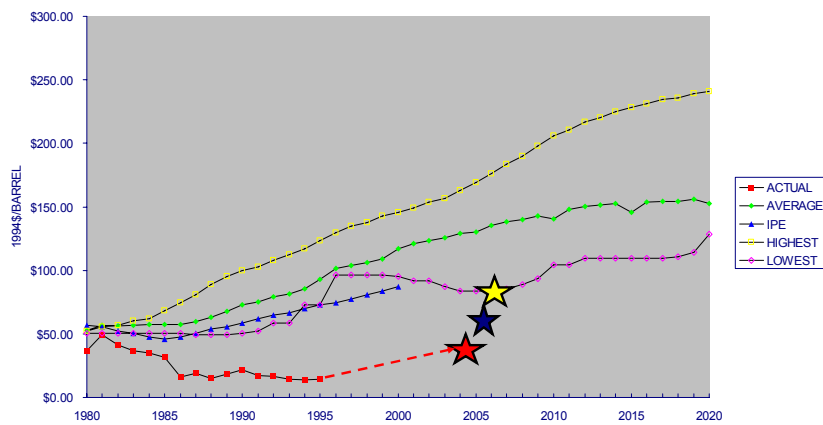
Source: M. Lynch, MIT

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EMF6 Oil Price Forecasts



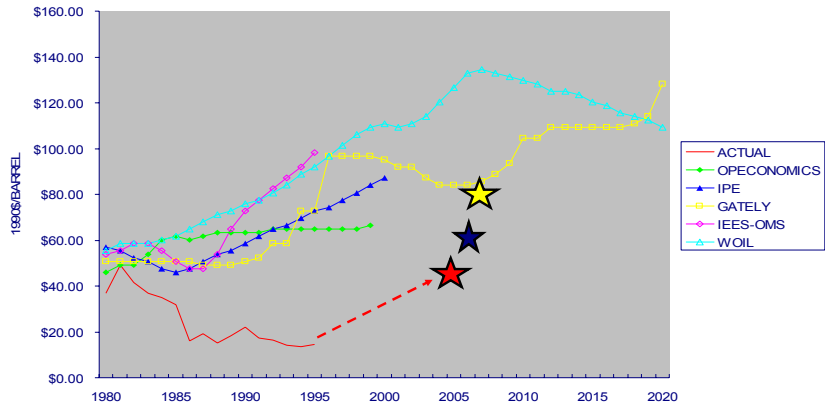
Source: M. Lynch, MIT

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EMF6 Oil Price Forecasts (Low)



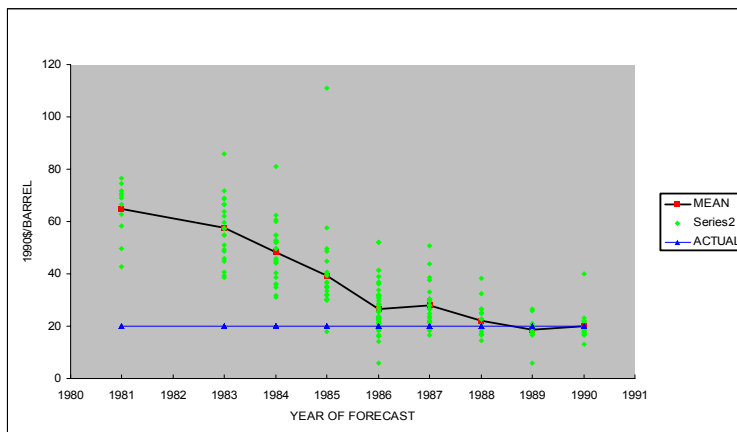
Source: M. Lynch, MIT

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Forecasts of 1990 Price of Oil



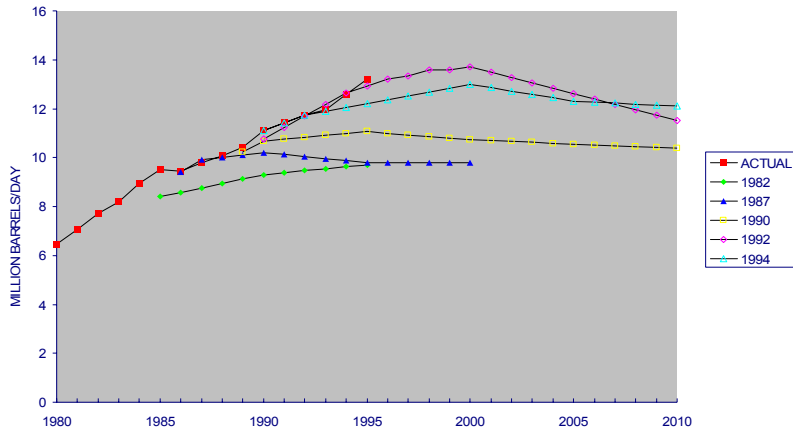
Source: M. Lynch, MIT -- IEW Survey

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DOE Forecasts Non-OPEC LDC Production



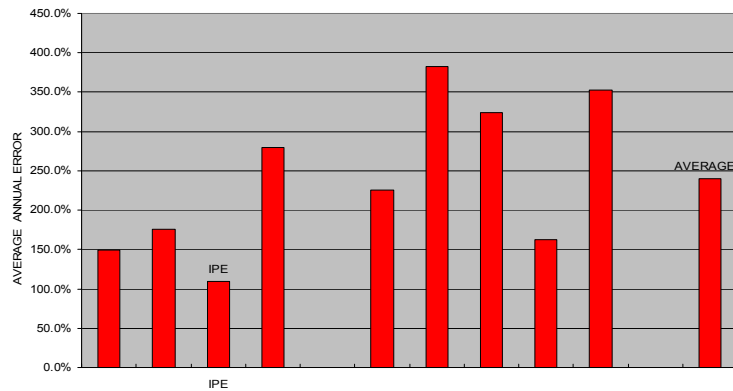
Source: M. Lynch, MIT

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Error in OPEC Revenue Forecast EMF6 1980 - 1995



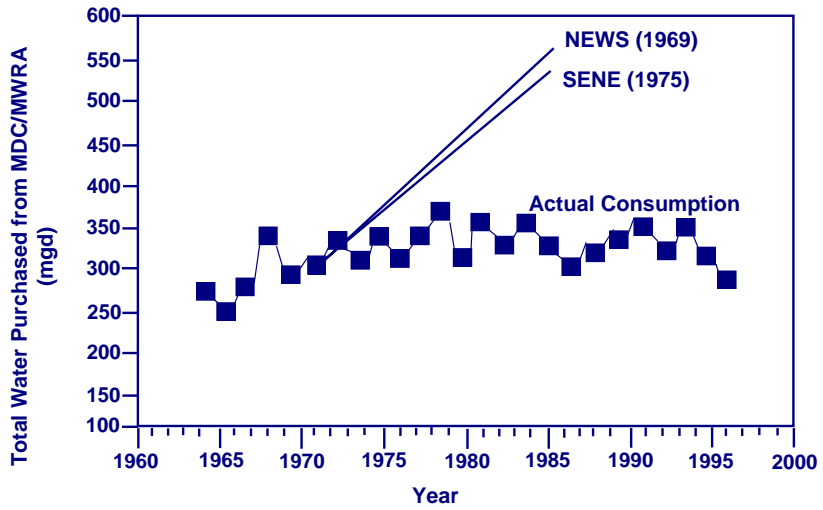
Source: M. Lynch, MIT

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Forecasts of Water Use in Boston (MWRA Members)

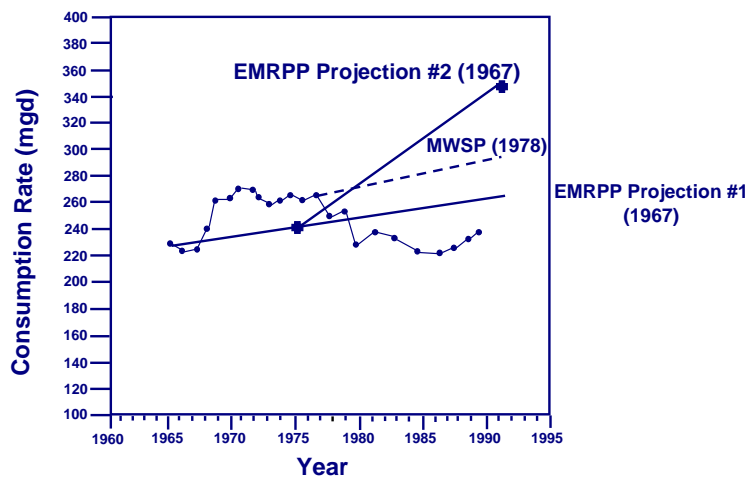


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Forecasts of Water Use in Boston (MWRA Service Area)



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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.**

Range Of Choices -- Limited View

- **The Usual Error**
 - Polarized Concept
 - Choices Narrowly Defined around simple ideas, on a continuous path of development
- **Examples**
 - Mexico City Airport: A Major New One Yes or No?
 - ◆ What kind of airport? International? Domestic? Military? General Aviation? Some Combination?
 - Compliance with Laws: As written? Yes or No?
 - ◆ Experience of Planning for Electric Vehicles for Los Angeles, California

Range Of Choices -- Correct View

- **The Correct View**
 - All Possibilities must be considered
 - The Number of Possible Developments, considering all the ways design elements can combine, is very large
- **The general rule for locations, warehouses**
 - Possible Sizes, S
 - Possible Locations, L
 - Possible Periods of Time, T
 - Number of Combinations: $\{S \text{ exponent } L\} \text{ exponent } T$
- **Practical Example: Mexico City Airport**
 - Polarized View: "Texcoco" of "Zumpango"
 - All Combinations: $\{2 \text{ exp } 4\} \text{exp } 3 = 4000+ \text{ !!!}$

Problem from Limited View of Choices

- **Blindness to "98%" of possible plans of action**
 - ◆ These are the "combination" (or "hybrid") possibilities that combine different tendencies
 - ◆ The "combination" designs allow greatest flexibility -- because they combine different tendencies
- **Blindness to many possible developments**
 - ◆ those that permit a variety of futures
 - ◆ because they do not shut off future decisions
- **Inability to adapt to risks and opportunities**
- **Significant losses or lost opportunities**

Real Range Of Choices

- **Practical Example: Mexico City Airport**
 - Most of the possible developments are combinations of operations at 2 sites (instead of only 1)
 - The simultaneous development at 2 sites allows the mix and the level of operations to be varied over time
 - The development can thus follow the many possible patterns of development that may occur
 - There is thus great flexibility
 - Also ability to act economically and efficiently
- **Recommended Action**
 - Acquire rights to Zumpango Site (this is an "option")
 - Wait until next 6-year Presidential term
 - Then decide next step

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

- **There are many design choices beyond the obvious ones**
 - ◆ ...Typically, they combine different characteristics
 - ◆ ...That enable different future developments
 - ◆ ... and are thus more flexible