Stochastic Dynamic Models

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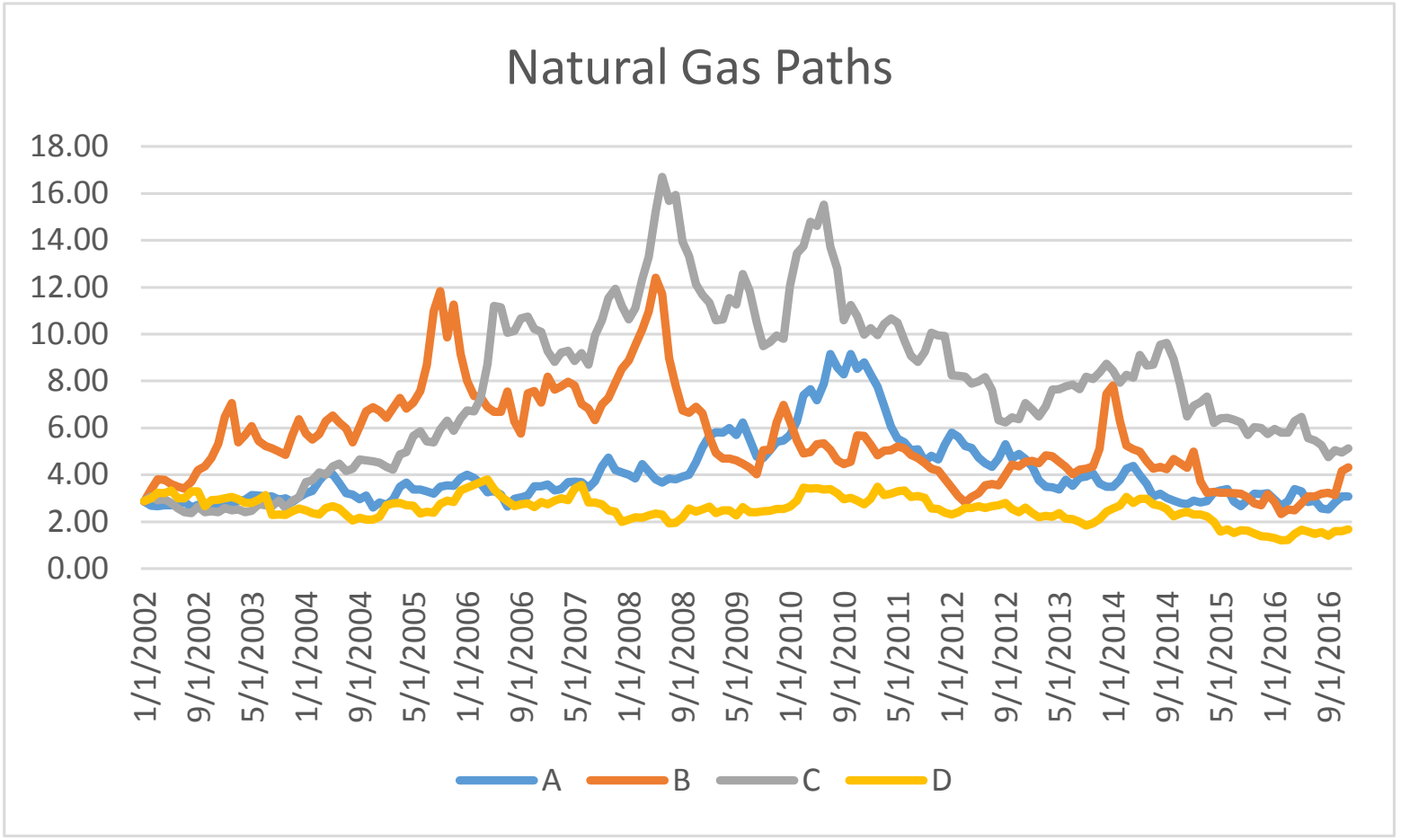
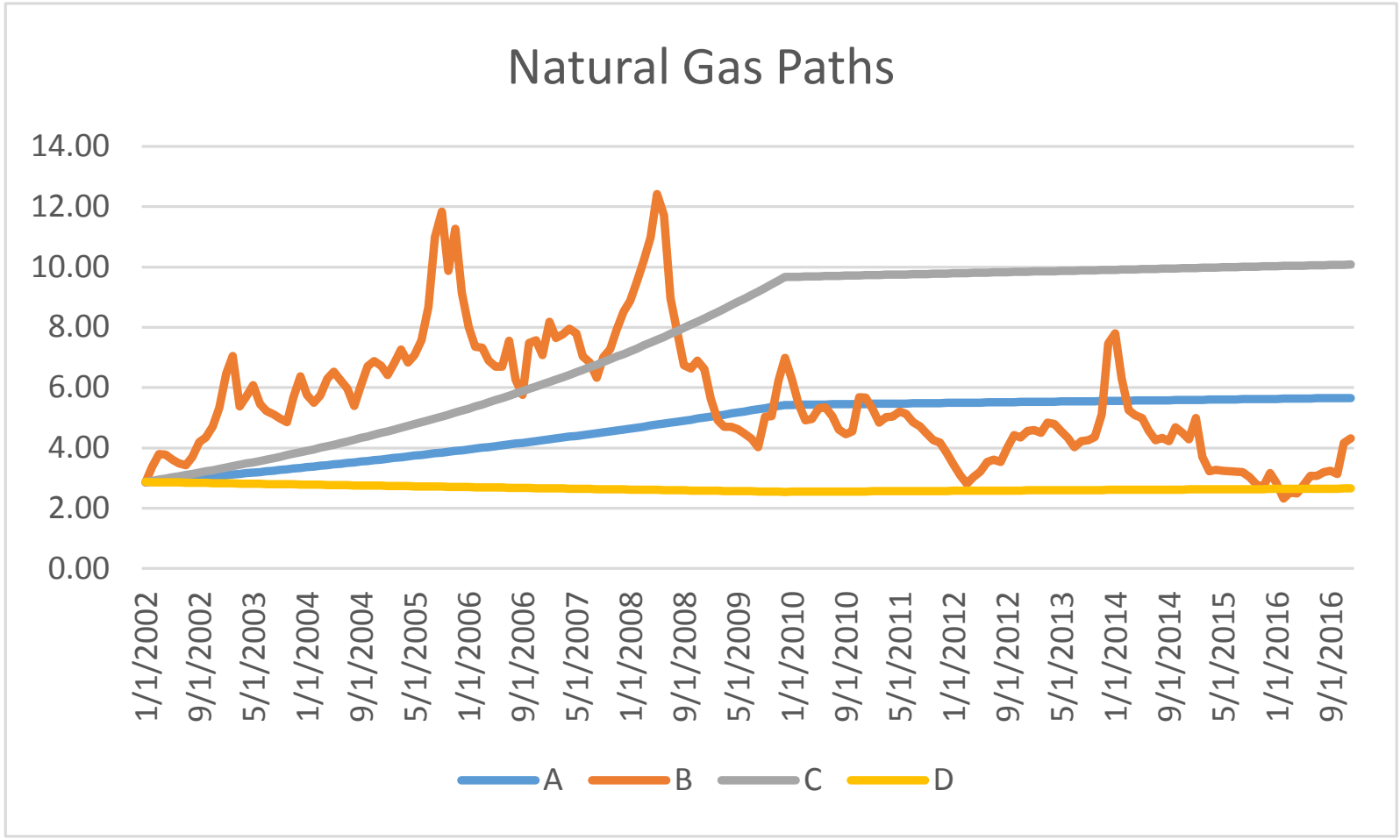
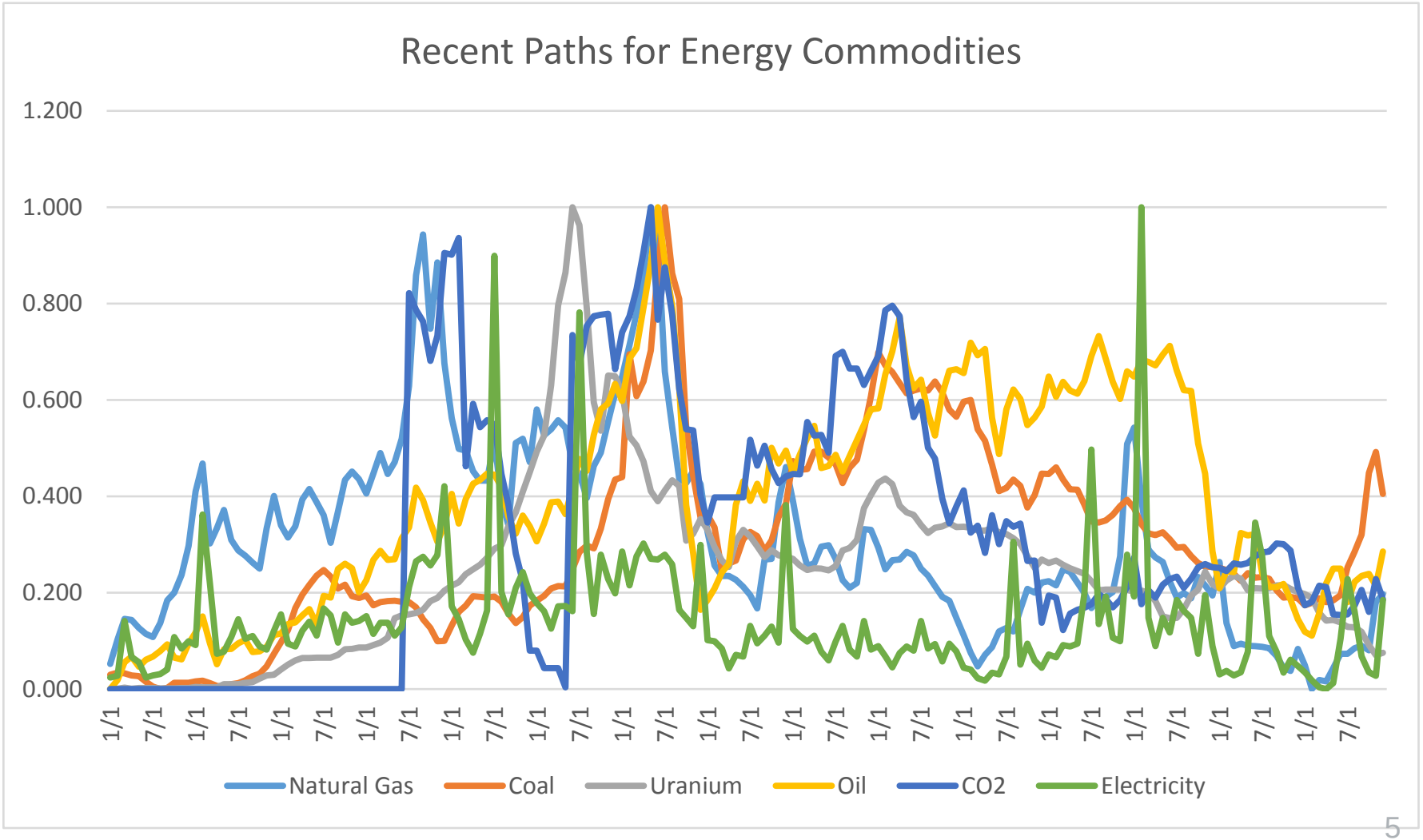
Which one is the real price path?



Which is the real price path?



Commodities relevant to electric power



What are forecasts used for?

- Long run planning – IRP
- Operations planning
- Risk management
- Valuation in disputes and regulation

What is common forecasting practice?

- Common practice
  - Most likely path
  - High & low path
  - Limited use of information
- Frequent problems with common practice
  - Meaning of Middle, High, and Low are often not well defined
  - Poor representation of uncertainty
    - No trend reversals
    - Low short term volatility
    - No mean reversion
  - Short and long term are often inconsistent
  - No logical process for updating

What is a Stochastic Dynamic model

- Describes a process, not a set of points
- Stochastic means a formal model of uncertainty
- Dynamic means that we can recalculate the model at any future point. That is, we can answer questions like, “If the price goes from $2/MMBtu to $4/MMBtu in 2020, what is the probability it is above $8/MMBtu in 2025

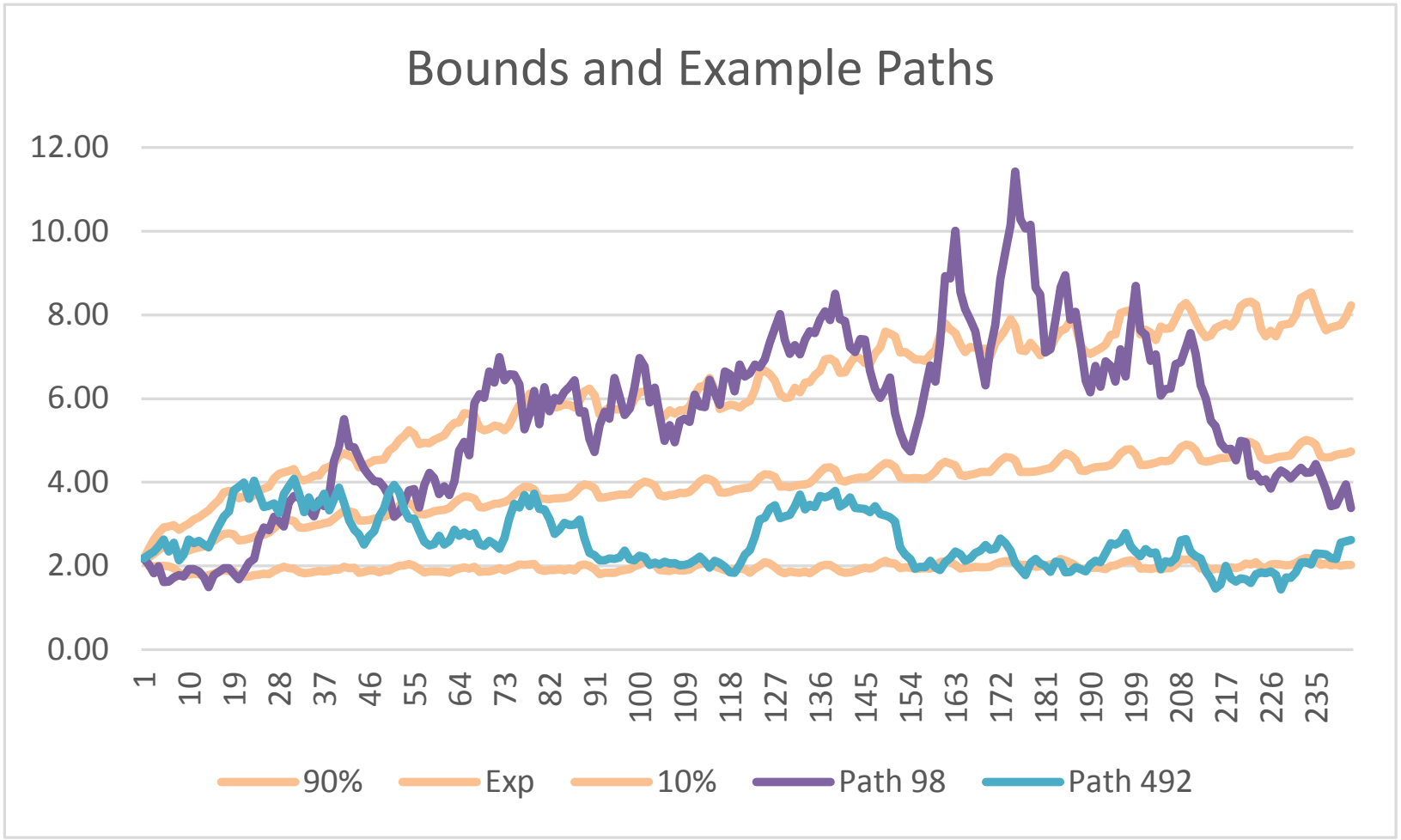
An important stochastic dynamic model for energy

- Schwartz-Smith Two-Factor Model
  - Review of the literature suggests that this is the most popular model for commodities
  - Also know as the Gibson-Schwartz model
  - Model has long term trend with short term reversion
  - Many simple and complex modifications to this model
    - For example, simple seasonality adjustments for gas prices
- Short-Term Variations and Long-Term Dynamics in Commodity Prices, E. Schwartz & J. Smith, *Management Science,* Vol. 46, No. 7, pp. 893-911

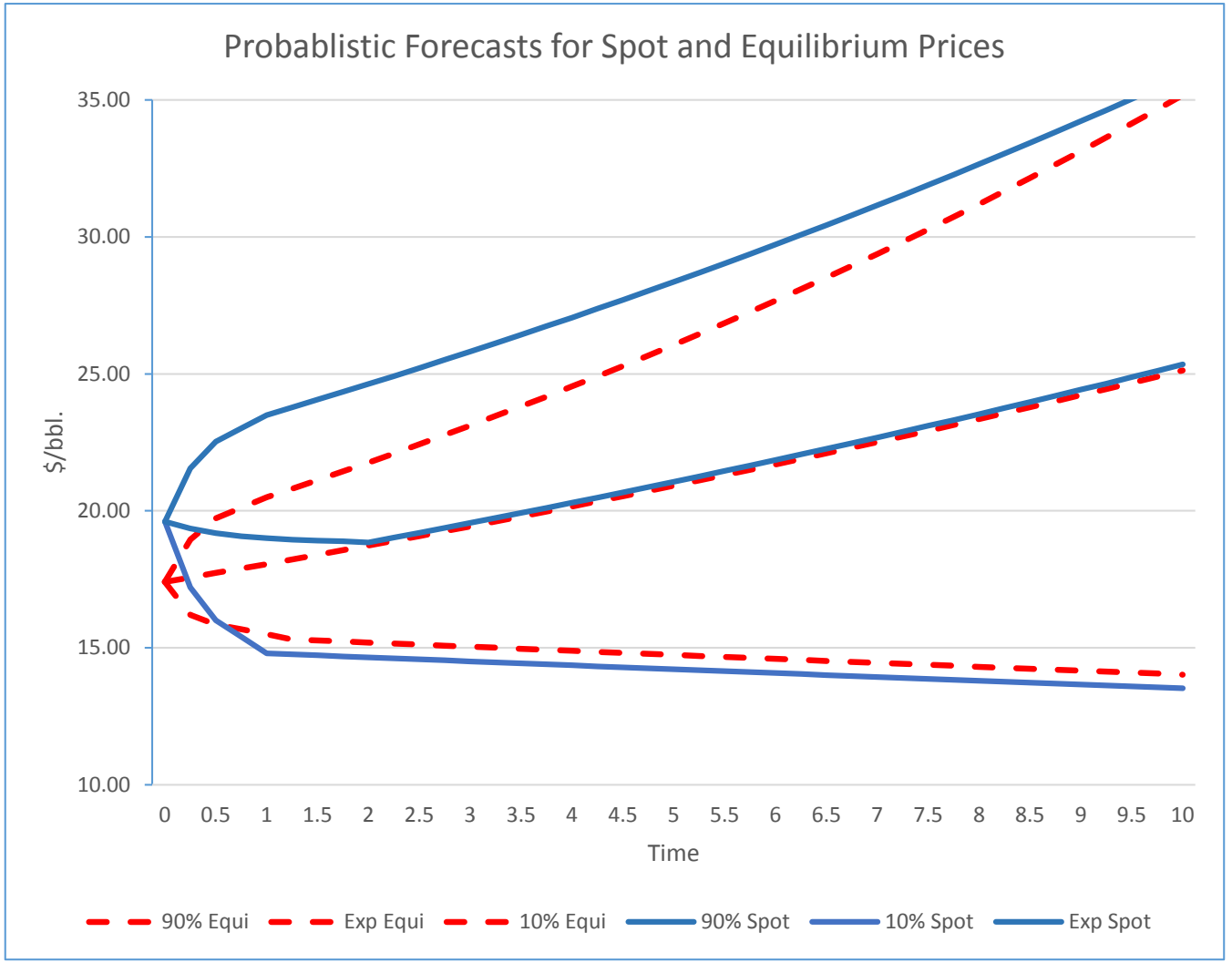
2-factor Model (only equation)

- $ln(S_t) = \chi_t + \xi_t$
  - χ_t is the short term deviation
  - ξ_t is the long term equilibrium
- $d\chi_t = -\kappa\chi_t dt + \sigma_\chi dz_\chi$
  - κ is the mean reversion
  - $\sigma_t dz_t$ is the random term
- $d\xi_t = \mu dt + \sigma_\xi dz_\xi$
  - μ is the trend
  - $\sigma_\xi dz_\xi$ is the random term

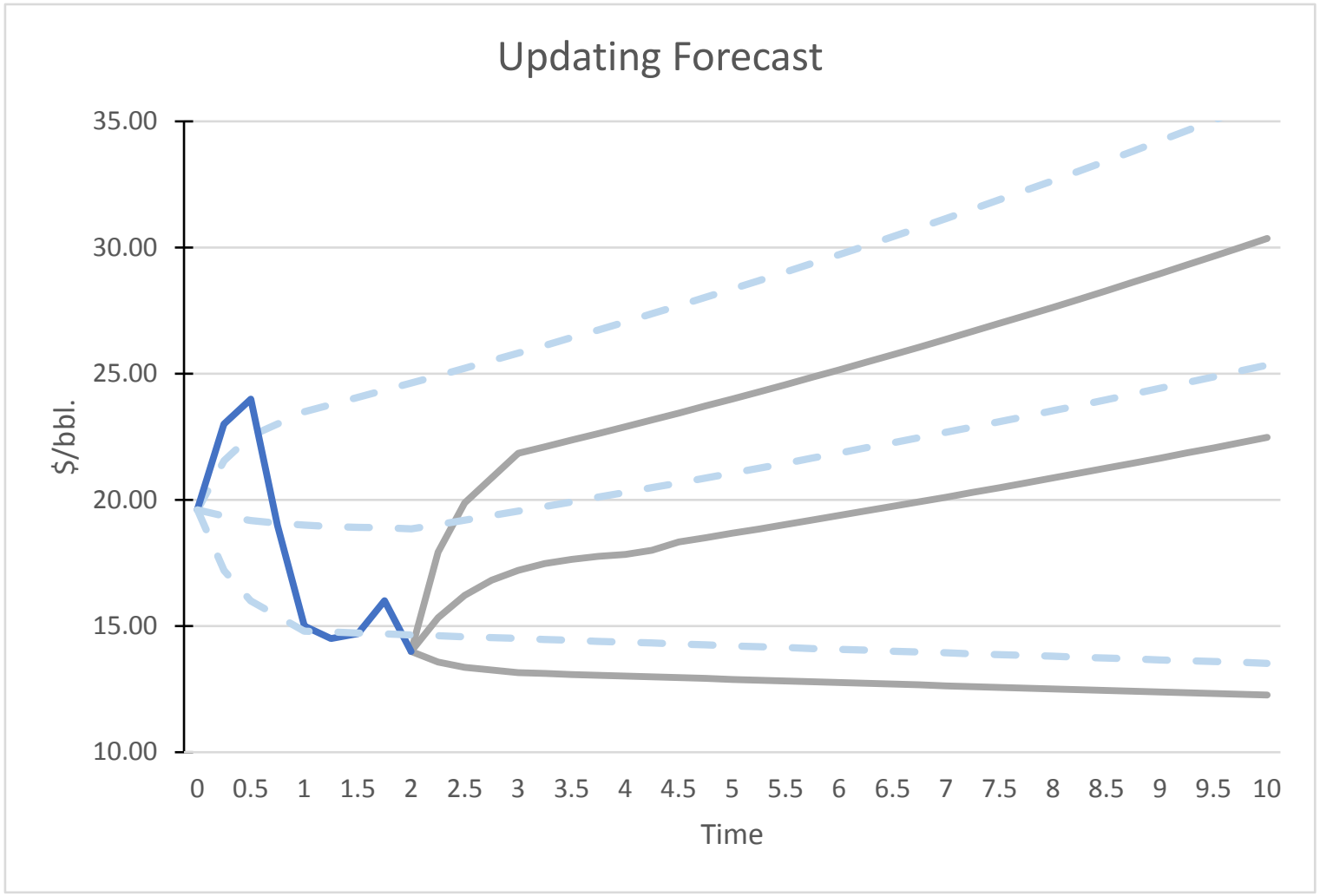
Example from risk analysis study



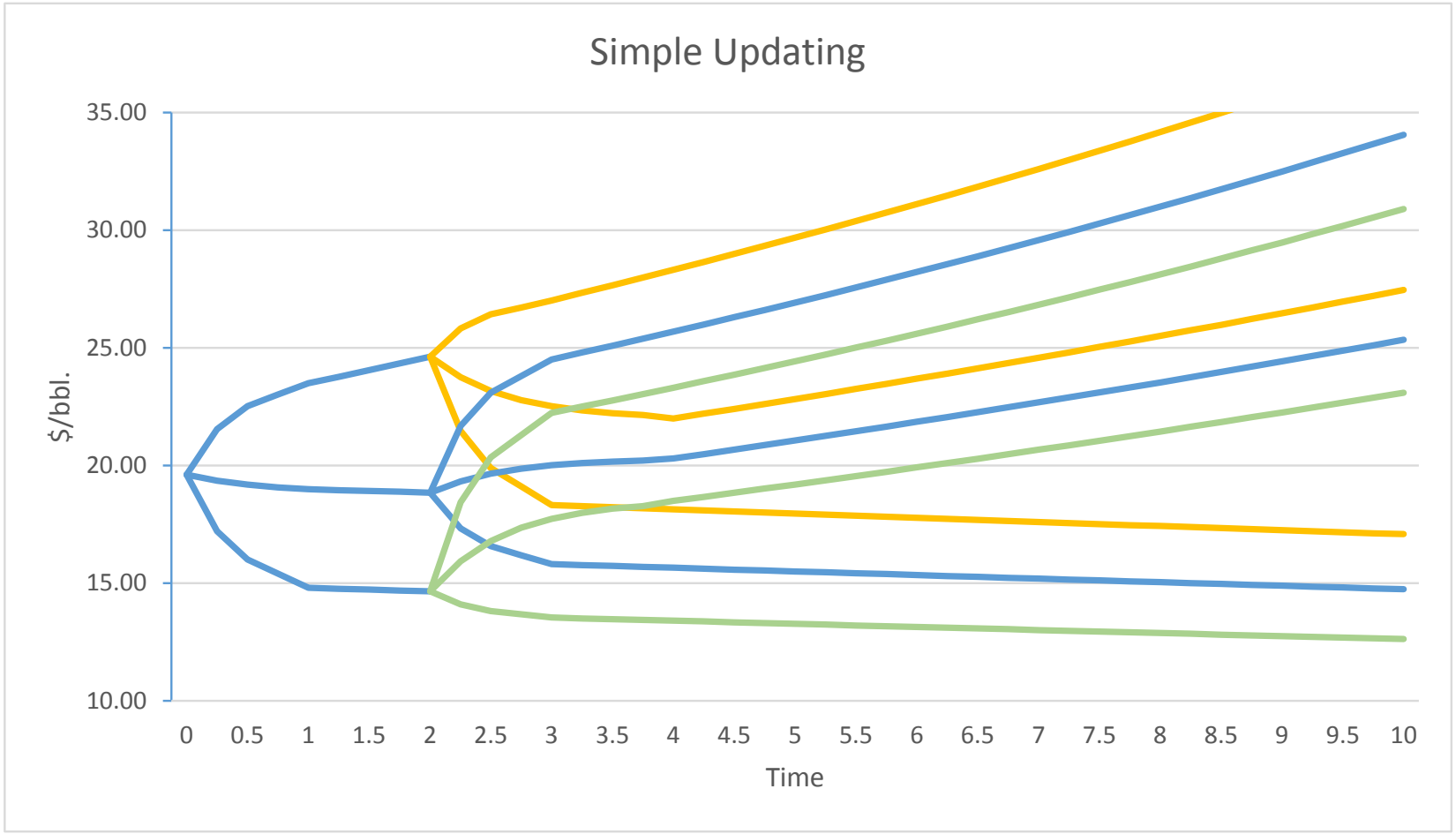
Illustrations of 2-factor model



Updating the two factor model



Update in simple decision tree

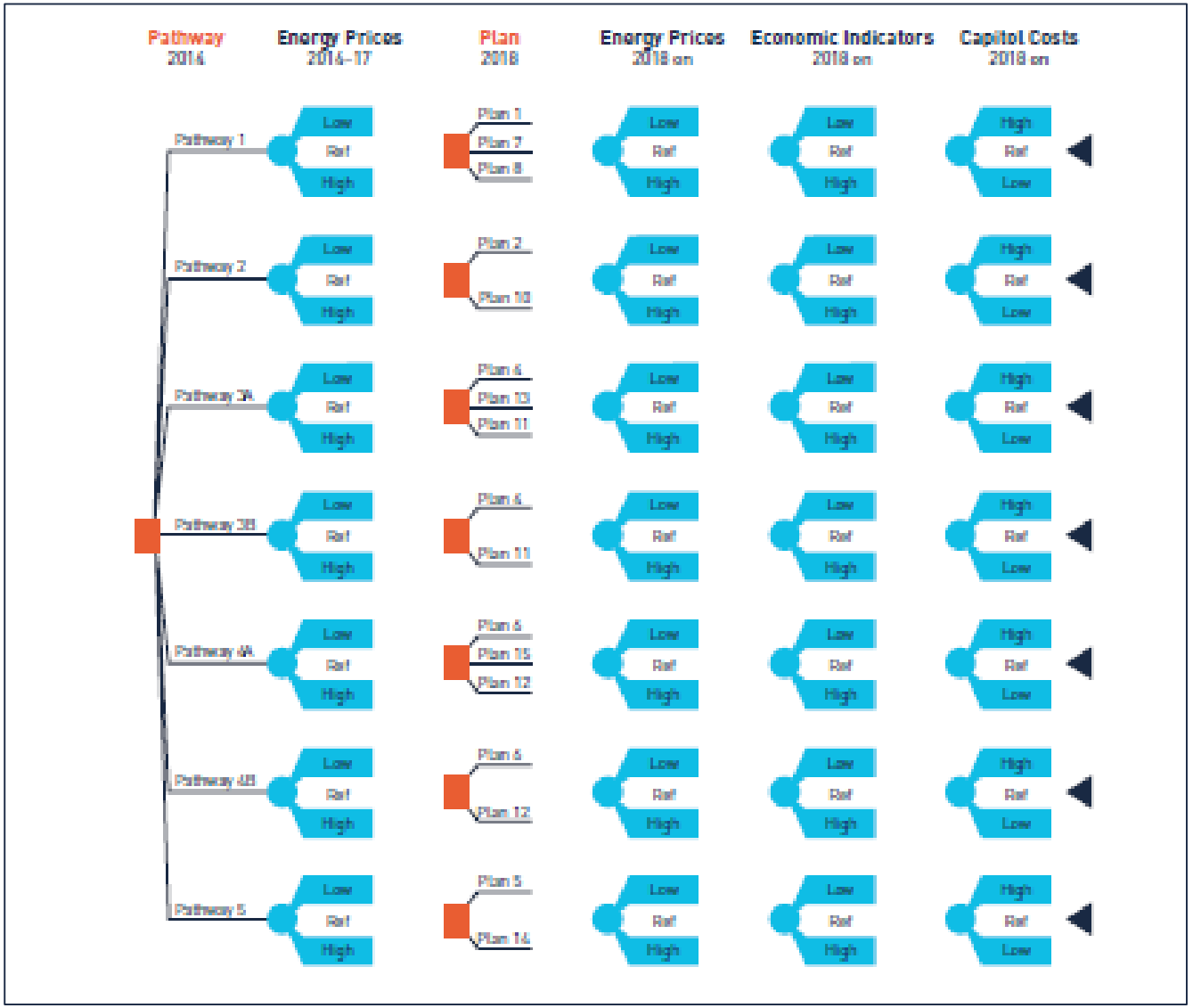


Problems with the 2-factor model

- Complex mathematics and complex to explain
- Requires judgment and experience to parameterize
- If paramaterized on macro-data such as historic or futures prices, can ignore impacts of new technologies, new policies, and other dramatic changes

– Manitoba Hydro, Needs for and Alternatives to, August 2013.

Example of a contingent plan



Uses of the 2-factor model

- Can provide price forecasts based on historical and/or futures prices
  - But also can be fitted to price paths of structural models
- Can be used to compare risk and reward from complex strategies using Monte Carlo simulation
- Can be used to form contingent plans if the decision structure is simple enough
- Can be used for contingent or recourse plans in two-stage stochastic optimization with resource planning models such as Polaris

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