

Screening Models

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Outline

- **Issue 1: Which Flexibilities add the most value to project?**
- **Issue 2: Why is this a challenge?**
- **Concept of Screening Model**
- **Development of Screening Models**
- **Types:**
 - **Bottom-up**
 - **Simulator**
 - **Top-Down**
- **Use in Practice**

Definition of Flexibilities: Why a Problem? Possible types...

Answer depends on:

- **Nature of System** –
 - mines vs. manufacturing;
 - small vs. large quantities
- **Kinds of Uncertainties**
 - State of Technology? Or of Demand?
- **Intensity of Uncertainties**
 - Slow or Fast Evolution (Subway vs. Google)
- **Cost of Implementing Flexibilities**

Definition of Flexibilities: Why a Problem? Complexity

The curse of dimensionality again!

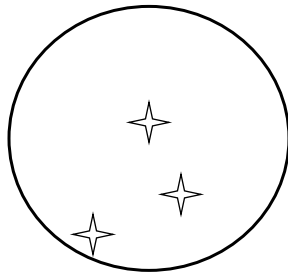
- **Too many combinations to explore**
- **Why?**
 - Complexity of design itself – creation of a single design for a oil platform may take a full day with “oil and gas” model...
 - Crossed with need to examine many scenarios scenarios of uncertainty over time – cannot in practice simulate hundreds of patterns
- **We simply cannot explore design space analytically**

Concept of Screening Model (1)

- A rapid way to explore design space systematically
- Substitute for designer “experience” or “intuition” -- an engineering approach
- Metaphor:
 - High Altitude flight over unknown territory, looking for special features
 - Can be complete
 - (But of course can miss some possibilities)

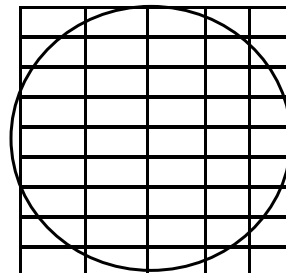
Concept of Screening Model (2)

- The image:



A few intuitive designs

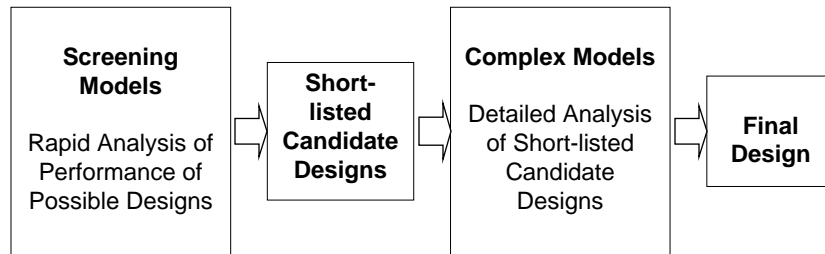
or



Systematic Search?

Concept of Screening Model (3)

- **Screening Models not a substitute for detailed models**
- **They define set of designs for detailed analysis**



Development of Screening Models

- **Desirable features;**
 - Rapid Analysis of Many Possibilities
 - Rank Designs reasonably accurately
- **How important is accuracy? Not much!**
 - Accuracy is not their function.
 - Their suggestions will be checked by analysis
- **This is an important distinction**
 - Practicing professionals want the “real thing”
 - Tendency needs to be resisted

Types of Screening Models

- **Bottoms-up:**
 - Simplified versions of detailed descriptions
- **Simulators**
 - Mimic detailed descriptions
 - Not necessarily “simulations” ...
- **Top-down**
 - Conceptual Representations of system

Bottoms-up Approach

- **Example: River Basin Development**
- **Full Analysis involves**
 - River Flow Model (channel, dams, diversions)
 - Hydrologic Model (rainfall, snow melt, etc)
 - Economic Model (Value of Power, Irrigation...)
 - Stochastic seasonal patterns of water flow, use
- **Screening Model**
 - Average Annual Flows
 - Optimization possible
 - Identifies reasonable possibilities

Bottoms-up Example (Wang)

Price of Electric Power Renminbi / KWH	Value of Project Renminbi. 10 ⁶	Optimal Characteristics of Dams					
		Site 1		Site 2		Site 3	
		Power MW	Volume 10 ⁹ M ³	Power MW	Volume 10 ⁹ M ³	Power MW	Volume 10 ⁹ M ³
0.10	0	0	0	0	0	0	0
0.13	367	3,600	9600	1,700	25	0	0
0.16	796	Same	Same	Same	Same	0	0
0.19	853	Same	Same	Same	Same	1,564	6,593
0.22	1,607	Same	Same	Same	Same	1,723	9,593
0.25	2,196	Same	Same	Same	Same	1,946	12,242
0.28	2,796	Same	Same	Same	Same	1,966	12,500
0.31	3,396	Same	Same	Same	Same	1,966	12,500

Source: Adapted from Wang (2005) p. 188.

Step 1: Optimize for Range of Conditions

Bottoms-up Example (Wang)

Site	Source of Option Value	
	Timing	Design
1	Yes	NO
2	Yes	NO
3	Yes	Yes

Source: Adapted from Wang (2005) p. 189.

Step 2: Identify Factors that might enter optimal design in different cases – these provide flexibility

Simulator Models

- **Idea is represent overall performance of detailed model using a simpler model**
- **We focus on output of the system, not on replicating its internal workings**
- **Largely a statistical exercise – to fit simple model with few parameters, to output of detailed model**
- **Two versions**
 - **Direct and Indirect**

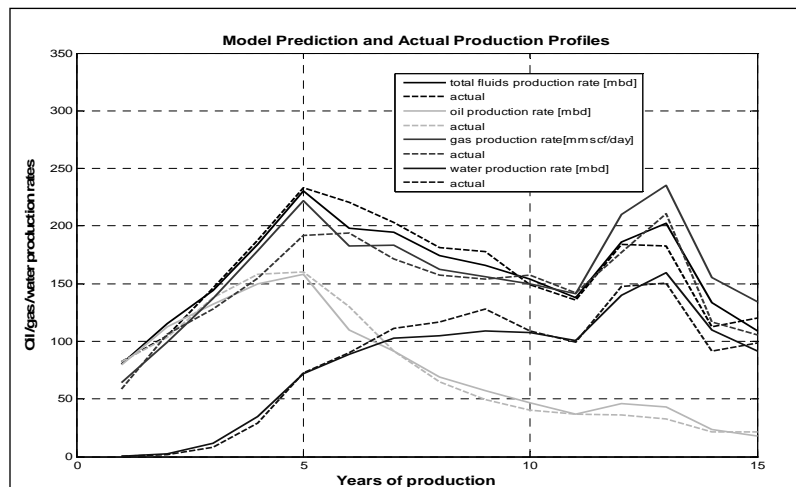
Direct Approach

- **Also known as “response surface model”**
- **Four Steps**
 1. **Select major factors (X_i) and vary them over a range (e.g.: Oil prices = 20, 40, 60, 80, 100, 120 \$/bbl)**
 2. **Run the detailed model with these values and obtain overall results (e.g. NPV of Project)**
 3. **Do statistical analysis to fit the factors (X_i) to output**
 4. **Result is Screening Model: Output = $f(X_i)$**

Indirect Approach

- Use first principles to construct simplified models of components of detailed model (e.g. mass balance equations)
- Assemble simple sub-models to create a complete model
- Validate by simulation

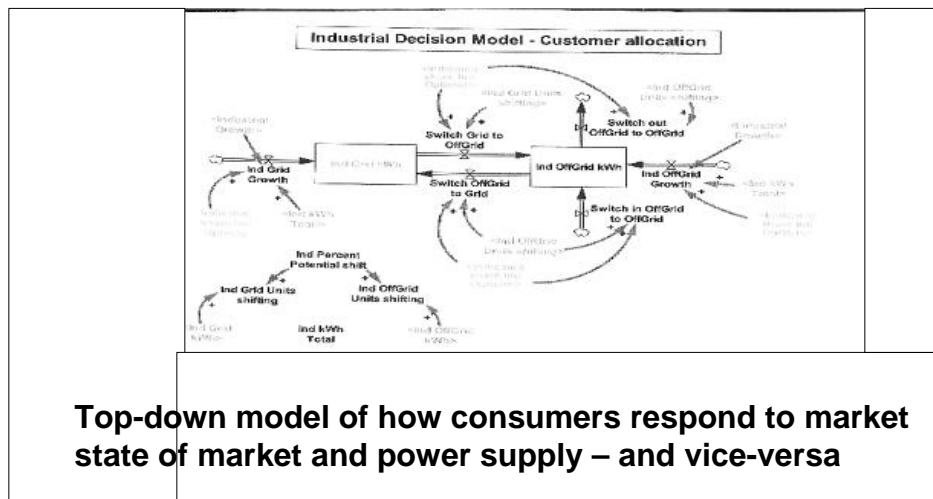
Validation of Indirect Model (Lin)



Top-down Approach

- Focus is on how major parts of system influence output
- Appears to be most useful when we have dynamic systems that evolve over time
- Best known examples use “Systems Dynamics”
- Preparing a good SD model requires a great deal of effort (Steel took about 2 years on model of Kenya power system)

Example of Top-down model (Steel)



Use of Screening Models

3 Approaches

- **Conceptual – get planners to “think outside the box” : Local hospital**
- **Optimization (e.g. Wang)**
 - Optimize for one configuration
 - Repeat for Others
 - Observe which components change
- **Patterned search – Like optimization, but not algorithmically driven**

Examples of Search Patterns

- **Possible Dimensions**
- **Phased Design -- smaller units (instead of larger ones)**
- **Modular – “plug and play” easy additions**
- **Design for Expansion – space, strength**
 - Parking Garage; Bridges over Hudson, Tagus
- **Platform Design – Chassis for cars (Suh)**
- **Shell Design – empty space available for future use (Mt. Auburn Hospital)**

Summary

- **Screening Models Very Useful in Identifying Opportunities for Flexibility**
- **Are complementary, not competitive, with detailed models of system**
- **Feed results into detailed models, and thus guide their direction**