Drivers of Flexibility

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The Issue

A key aspect of flexibility is to delay design and management decisions

What are the factors that encourage, drive us to use flexibility?

What are the contrary factors that favor immediate decisions?

Overall -- When should we actively look for flexible solutions? And when might these not be so favorable?

5 Principal Drivers

The principal factors driving the desirability of Flexibility are:

1. Uncertainty
2. Economies of Scale
3. Discount Rate
4. Learning
5. Competitive Gaming

Driver 1: Uncertainty

- What is Uncertainty? How do we define it?
- How does it relate to Risk?

A lot of linguistic discussion about this...

- "Risk" implies bad things
- "Uncertainty" is neutral ... Could include good outcomes. Preferable term for me.

In general, a range of future possibilities

Uncertainty and Flexibility?

What's the connection?

We could do better if we knew the future

Moreover, the greater the uncertainty...
the better we can be when we know future …
he greater the value of flexibility
the more we should have flexibility!

Flexibility Always?

Question: Isn't future always uncertain? Don't we always want flexibility?

NO!

Why is this?

2 main reasons against flexibility always

1. **Economies of Scale**
2. **Competitive Gaming**

Driver 2: Economies of Scale

What are Economies of Scale?

The idea is that for many systems larger units of capacity (greater scale) can deliver lower cost (economies) per unit of production than smaller units

- **Let's examine concept in detail**

What's the Intuition?

A common driver for existence of economies of scale is that

- Cost of unit of capacity is f(area)
- Production is f(volume)

Examples:

- Thermal Power plants,
- Ships, aircraft
- Pipelines, Transmission lines

Concept of Cost Function

"Cost Function" is

- an important economic concept
- NOT just the cost of any design

Cost function = C(Y) = cost of economically efficient design, as a function capacity, Y

Note: As size (scale) increases, the optimal design changes. For example, as volume of a container increases, surface of material doesn't increase as fast.

Economies of Scale: Formal Concept

Possible characteristic of cost function

Economies of scale exist if costs increase slower than product,

Total cost = C(Y) = Y^{α} $\alpha < 1.0$

Reasonable lowest value $0.6 < \alpha$

C(Y) = F(prevailing local cost conditions)

E of S imply that it's more efficient to build large plants that smaller ones...

Mantra of Engineering design BUT...

Large plants inefficient if not at operating at capacity!

If large plant not operating at capacity

its unit costs of production can easily become exceed those of smaller plant

Actual Economies of scale may not exist !

Facility size (units)	1 million	2 million
Economies of scale factor	0.7	0.7
Plant cost	1 million	1.62 million
Unit cost for		
2 million units		0.81
1 million units	1	1.62
0.5 million units	2	3.25

Driver 3: Discount Rate (Review)

What is it? How do we define it?

Rate used to place all revenues and cost on same basis over time
Like an interest rate – but not – WHY?

Should represent "opportunity cost" of money, the value (at the margin) that you can get for it in best alternative use

Possible values used net of inflation:
~ 8% ordinarily, ~ 15% if high risk

How does Discount rate impact Desirability of Flexibility?

When the demand for capacity is growing (as for electricity, for example) 2 choices:

A) Build Big now, for many years ahead
B) Build small now, add small units later

Choice A based on economies of scale

Choice B makes later investments cheaper in present value terms. It also can save money if forecast demand does not arrive.

Discount rate counterbalances E of Scale

Driver 4: “Learning”

What is it? How do we define it?

“Learning” is an empirical observation:
Production of more units => lower unit cost
we avoid mistakes, become more efficient, adopt other incremental improvements
(‘learning’ may also include better design)

“learning curve” plots as log of production
Unit Cost $U_i = U_1 \, i^B$
B is the slope of the learning curve

Effect of "Learning"

"Learning" amplifies Discount rate effect

When comparing Choice A (build big) and Choice B (small modules), "learning" adds to discount rate in terms of making future small modules less expensive in terms of present values.

Driver 5: Competitive Gaming

What is it? How do we define it?

Not a simple matter to define inclusively

Basically, sometimes it is advantageous to make a firm commitment in advance, as signal to competitors

Example: "Cortez burning his ships"

Tendency of Principal Drivers

The principal factors driving the desirability of Flexibility are:

1.	Uncertainty	FOR
2.	Economies of Scale	AGAINST
3.	Discount Rate	FOR
4.	Learning	FOR
5.	Competitive Gaming	AGAINST