[SQUEAKING]

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RICHARD DE NEUFVILLE: There are two main reasons why we might not want to delay decisions. The main one is, perhaps, economies of scale. And the second one is competitive gaming. So let me address the first one next. But the answer is there are reasons why you don't want flexibility. And here is an economic one.

So what are economies of scale? The basic idea is that for many systems, larger units of capacity-- that's what's meant by greater scale-- can deliver lower cost economies per unit of production than smaller units. One big electric plant is cheaper than two smaller plants with a same total capacity.

So first of all, let's think about what's the intuition? The common driver for the existence of economies of scale is that the cost of unit capacity is a function of its area. And the production is a function of this volume. Now there are many more subtle aspects of it. But think about it in terms of, say, thermal power plants, where the whole idea is you boil water, and you use the steam to drive engines on.

The same thing as for catalytic tracker plans, for all kinds of processing, where you're dealing with vats and so forth because the capacity is the volume that's inside this, and the material used to contain it is a function of the area. It's the same thing also for ships, for example, that the capacity is a function of the volume, but the resistance to it's forward motion is a function of it's surface and so and the same kind of thing with reasoning with aircrafts and so on.

So there's a fundamental reason that in a lot of things that we do, units of production, that we have the possibility of economies of scale. Now there's all kinds of subtle ways of going into that. But what I would like to leave you with is there is a reason for this for which there is a simple, intuitive initial driver. And so it's a prevailing observation in many industries that this is the case.

Now to understand this better, I want to introduce the notion of a cost function. Now, the cost function is not just the cost of any design. They said, OK, I'm going to design a steel plant, or I'm going to design a supply chain. I'll add up all the things I put together. That's the cost. No. The cost function is an economic concept of the most efficient design as a function of capacity.

Now, there's two elements of it. One is that as you change from a small capacity to a larger capacity, another larger capacity, the design changes. That is, you don't scale everything up exactly the same. You do different things. If you're building a building, if you're correcting a building or a warehouse something like that, what you do for design for one story is not the same thing as you do for design of 20 stories. You have different elements of it that allow you to do that so that the design changes with capacity.

And the second aspect of it is it's the cost of economically efficient design. What that implies is that the cost of the economically efficient design may be different in the United States, Europe, Asia, South America, wherever. Why is that? Because to produce something, you want to put various things together.

You want to have machines. You have the cost of labor. You have the cost of land, the cost of building, all these things, the cost of the raw materials so that the cost really depends upon the local economy and how it's working. Steel may be very expensive in places far from the steel mills, and therefore, they don't use steel as much as elsewhere. So the economically efficient design is associated not only with the time and place where you are, but also with the size.

So we're talking about not the cost of any design. We're talking about the cost of an economically efficient design with the idea that your design is among that set. So we can then talk about this cost function as a concept.

Now to move on, the economy of scale is a characteristic of the cost function. So they exist if costs increase slower than the product. So if we look at the function of down on the third line here, of C(Y), the cost function as a function of product, as it relates to product,

I've put this in the standard notation an alpha here, again standard notation-- the Greeks very often are honored by the exponents for them-- so that if alpha is less than 1, that is if we double the amount of capacity here, going from one unit to two units, that the cost, if the exponent is less than 1, the cost doesn't go from $1 million to $2 million, it goes from $1 million to $1.9 million or $1.8 million, something like that.

Now, it is a way of expressing the notion of the economies of scale. And one can make studies of different industries at different times and different places. I can refer you to some of them if you're interested in. But this is a common way of expressing the economy of scale.

Now, it's not a yes/no situation. It is some industry to some products have a higher or greater economies of scale or lower economies of scale. It depends on the value of this alpha. And as a benchmark, for a variety of reasons, the alpha is generally greater than 0.6, which is about the threshold about how low economies of scale can go.

So a common exponent in various industries is about 0.8, 0.9. It's clearly significant economically. But it's a range. It's not yes, it has it, or no, it doesn't. Now the existence of this says that from the definition of the cost function in relation to capacity, is economies of scale imply it's more efficient to build large plants and smaller plants.

And this is in many ways a mantra of engineering design. It prevails in design of power plants, in designs of platforms, and design of processing plants of all kinds. And that's why I call it a mantra of engineering design. It's common. It say's, OK, we're going to do it right, boys and girls. We're going to have a big efficient plan. We're not going to mess around with these smaller ones.

But the large plants, it is also it's assumption built into the notion of economies of scale is that they're operating at capacity. Now, the fact is that if you're in an area and you are, say, building power plants and you just don't build for the minimum amount, but you say, well, we're going to build it. We're going to build for what we need over the next 5 or 10 years, you build it larger than you need now.

So generally speaking, very often a large capacity plant isn't fully utilized from the start. And therefore, it's operating inefficiently for quite some period. So take a look at this simple example I've shown below. I have a a plant of 1 million or 2 million of widgets. I have an economies of scale factor, alpha.

I have the plant cost is $1 million for the for the smaller one. If I double the size and I multiply this by 2 to the 0.7, instead of doubling the cost from going from $1 million to $2, million goes to $1 million to $1.6 million. That's very good.

Now let's look at the unit cost for the production. If I produce 2 million units, I'm getting it at 0.8. So that looks good compared to the cost I have from a small unit. But if I only needed half a million units or a million units, and I was operating a big plant-- I've paid for this big plant, but I'm running it at half speed, and I've got all this big stuff that I'm not using, the cost per unit then becomes much greater.

And if the actual need is only half of what I had anticipated, the cost per unit of the smaller plant goes from 1 to 2. The cost per unit or the other one goes from 1.6 to 3.25. So the plants, which are big plants, which are designed to produce efficiently for their intended capacity, note that its intended capacity, not the demand of the use that actually happens. That is they can seem to be very efficient. But if the demand isn't there or they aren't using it for whatever reason, then the cost per unit produced, as opposed to capacity, can be very much greater.

Now, this particular example is a very simple illustration to suggest the point that I'm trying to make here. But in detail, there's a lot more factors that will go in to than this toy example here. But the basic idea is that plans designed around the notion of economies of scale don't necessarily make it cheaper when, as can happen, either because it's a growth market or because of a demand is not there, may in fact be much more expensive. That is what I would like to leave you with at this particular moment.