Business Data Management
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Cost Curves

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Number of workers	Output (quantity of pizzas produced per hour)	Marginal product of labour	Cost of factory	Cost of workers	Total cost of inputs (cost of factory + cost of workers)
0	0		€30	€0	€30
1	50	50	30	10	40
2	90	40	30	20	50
3	120	30	30	30	60
4	140	20	30	40	70
5	150	10	30	50	80

Professor M Suresh Babu: So broadly, these are the concept of costs. Now, let me just show some numbers on this so that the concepts are a little clear. Now, I am going to start this pizza factory and I have just bought the land and machinery and everything, now we are going to start production. Initially, I have purchased this factory shed. I have also purchased the machinery for making pizza, so that is the initial investment going as 30 euros or 30 dollars or whatever it is. So, then we are looking at that as a fixed cost. With these 30 dollars or euros that we are using, you can produce up to a certain level of pizzas. So, the maximum I can go up to is 200 pizzas per hour.

Professor G. Venkatesh: Okay.

Professor M Suresh Babu: But depending on my demand, I will vary my production. So initially, I have not hired any worker, I have just bought the machinery and installed it.

Professor G. Venkatesh: You are not doing it yourself. You just bought machinery.

Professor G. Venkatesh: So far no demand.

Professor M Suresh Babu: No demands and I have not started my operations. But please remember, even at that point, I have incurred a cost. That is the cost of machinery, which is a fixed cost. Now, I thought that I would hire one worker and this worker is quite good and produces 50

pizzas per hour. Then there is a marginal product of this labor, that is, this one worker is producing 50 units of output that is the marginal product of that laborer whom I have hired, so the concept of the marginal product becomes very important here.

Then my cost of factor remains the same. It does not vary because it is a one-time factory investment that I have made. Cost of workers, I have to pay this worker a salary or wage or daily wage or whatever it is, so I am giving 10 dollars or 10 euros for that, then my total costs increase. 30 euros I have already incurred for the factory and 10 for labor.

Now, please remember I have not added the material costs. Right now, I have some material with me I am producing with that.. We can complicate it with material cost and energy costs, all variables. Then I keep increasing production, then my marginal product of labor keeps falling. Initially, it was 50 units then 40 then 30, 20, 10. Now, I find one parallel here from our consumption theory, that is, remember we talked about the marginal utility of consumption.

Professor G. Venkatesh: Marginal utility.

Professor M Suresh Babu: Now, and we also discuss that the marginal utility keeps falling after a point.

Professor G. Venkatesh: Diminishing. It starts diminishing.

Professor M Suresh Babu: Exactly like that. We find a very peculiar situation here: if you have one factor of production fixed and keep varying the other factor of production, initially, the marginal product will be high. After that, it starts falling. And that is exactly the parallel that we find from demand theory as well. So, the cost to workers will keep increasing as I hire more and more workers, so my total costs also increase. My fixed cost remains the same, but my variable cost that is the labor wages, keeps increasing.

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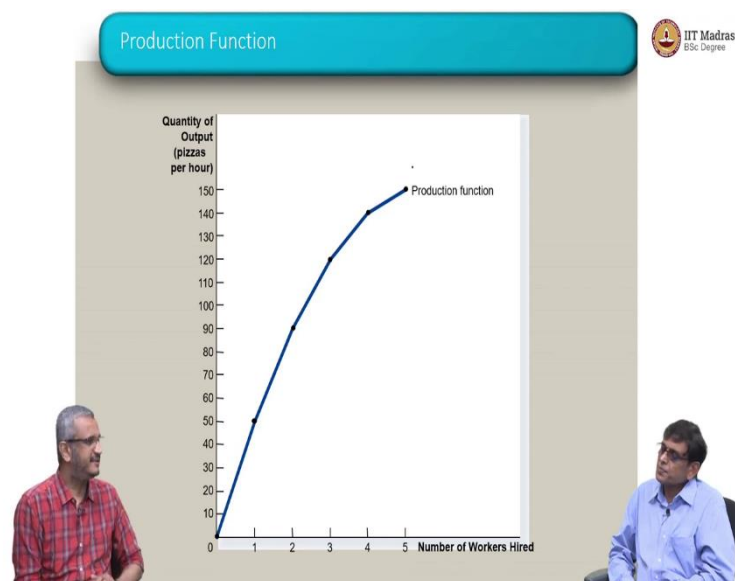
Professor G. Venkatesh: Unit cost, so per pizza, if you look at it, it will look much more interesting.

Professor M Suresh Babu: Yeah. We will see how that concept comes in. So, we can plot in terms of quantity of production and the number of workers hired and we can have a relationship.

Professor G. Venkatesh: Correct.

Professor M Suresh Babu: So, that is a very simple kind of a production function to which we will come later in our discussions.

Professor G. Venkatesh: So, what is this production function?

Professor M Suresh Babu: Production function is, the kind of a relationship between inputs and outputs.

Professor G. Venkatesh: In this case, output pizzas.

Professor M Suresh Babu: Output is pizzas, and input is the worker.
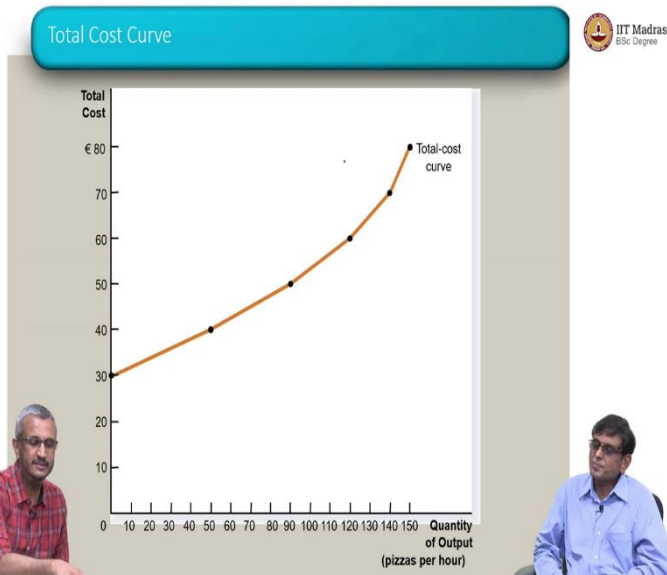
Professor G. Venkatesh: Only worker that you are concerned with.

Professor M Suresh Babu: Only worker, only that I am concerned, variable.
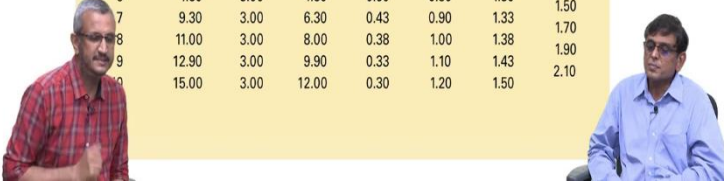
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Number of workers	Output (quantity of pizzas produced per hour)	Marginal product of labour	Cost of factory	Cost of workers	Total cost of inputs (cost of factory + cost of workers)
0	0		€30	€0	€30
1	50	50	30	10	40
2	90	40	30	20	50
3	120	30	30	30	60
4	140	20	30	40	70
5	150	10	30	50	80

Professor M Suresh Babu: Now, let us come to this whole example again regarding the total cost curve. See, this is the total cost. Initially, it was 30, 40, 50, 60 it goes, so the total cost curve is always increasing. Even though your fixed cost is the same, your variable cost is increasing to pull up this, so it is always an increasing curve.

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The Various Measures of Cost: Lemonade Shop

Quantity of lemonade glasses (per hour)	Total cost	Fixed cost	Variable cost	Average fixed cost	Average variable cost	Average total cost	Marginal cost
0	€3.00	€3.00	€0.00	–	–	–	€0.30
1	3.30	3.00	0.30	€3.00	€0.30	€3.30	0.50
2	3.80	3.00	0.80	1.50	0.40	1.90	0.70
3	4.50	3.00	1.50	1.00	0.50	1.50	0.90
4	5.40	3.00	2.40	0.75	0.60	1.35	1.10
5	6.50	3.00	3.50	0.60	0.70	1.30	1.30
6	7.80	3.00	4.80	0.50	0.80	1.30	1.50
7	9.30	3.00	6.30	0.43	0.90	1.33	1.70
8	11.00	3.00	8.00	0.38	1.00	1.38	1.90
9	12.90	3.00	9.90	0.33	1.10	1.43	2.10
10	15.00	3.00	12.00	0.30	1.20	1.50	

Professor M Suresh Babu: Let us look at this in terms of per unit and things of that sort, which will give us a better picture then. So, the total cost then is fixed, it is not varying. The variable cost keeps changing because here I am not talking about pizza, I am talking about a very simple example of a lime juice shop. And for producing one unit of lime juice, I have these initial lemons and whatever kind of lemonade baking unit and things of that sort. Still, if the variable cost keeps increasing, then we can compute the average fixed cost and compute the average variable costs. Average fixed cost is nothing, but total costs by the total units produced.

$$Average\ fixed\ cost = \frac{total\ cost}{total\ units\ produced}$$

Professor G. Venkatesh: Which will keep decreasing.

Professor M Suresh Babu: Which will keep decreasing.

Professor M Suresh Babu: Only one time you are actually investing. The average variable cost is very interesting. Initially, it is less but then it keeps increasing because you are adding more and more workers.

Professor G. Venkatesh: When you add one more worker it will again fall. It will increase rather. The step function increases.

Professor M Suresh Babu: So, we find that from point 3, point 5, point 6, point 7, it keeps increasing.

Professor G. Venkatesh: Alright.

Professor M Suresh Babu: Now, we have the average total cost, which is nothing but average fixed cost, plus average variable cost. But then we also remember when we started our discussion, we made this point that a lot of decisions are made at the margin. So, if I have to make a decision, as to, now I am producing 3 units or 3 glasses per hour, should I increase the output to 5 or 6 at the margin? If so, what is my cost? So, we introduce a concept called marginal cost. And the marginal cost is very interesting because we find that marginal cost also keeps increasing because the variable cost keeps increasing, so the marginal cost is pulled up. Now, let us put everything in perspective.

Professor G. Venkatesh: Variable cost keeps increasing, but the increase may not necessarily be at the same rate as the number of items produced.

Professor M Suresh Babu: Yeah. So.

Professor G. Venkatesh: So, per item, it might actually be.

Professor M Suresh Babu: So, then at that point, I will have to decide whether I should expand my production or not. That is the point that I was trying to get through.

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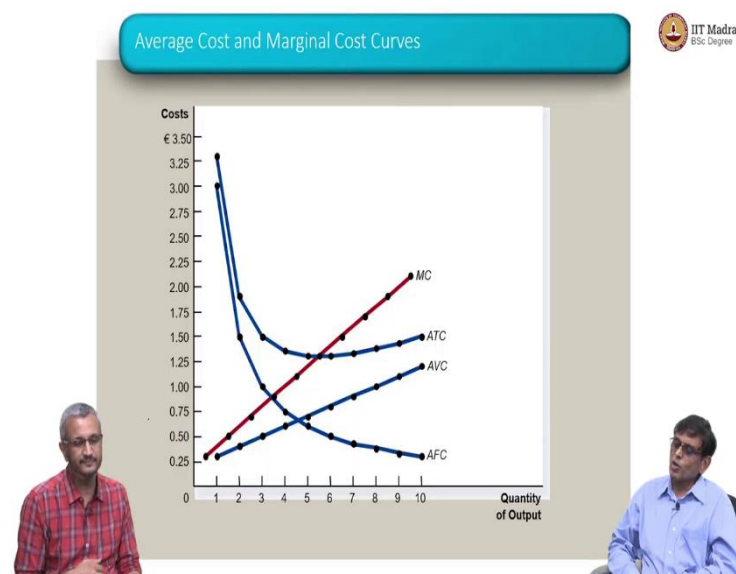
Professor M Suresh Babu: So, I am plotting all this into a slightly clumsy graph. Now, we have the average fixed costs, it keeps falling. We have the average variable cost it keeps increasing. Average fixed cost and average variable costs will give us the average total cost.

Professor G. Venkatesh: Sum of the average fixed cost and average variable cost.

Professor M Suresh Babu: Yes.

Professor G. Venkatesh: Is the average total cost.

Professor M Suresh Babu: And we have the marginal cost.

Professor G. Venkatesh: Which is also increasing.

Professor M Suresh Babu: Which is increasing. Now, depending on this, I will decide where I should locate my production.

Professor G. Venkatesh: How do you do that?

Professor M Suresh Babu: There are too many curves. I will come to that in a minute.

Professor G. Venkatesh: But the shape of these curves is typical. I mean.

Professor M Suresh Babu: These are typical.

Professor G. Venkatesh: Because I mean, this average fixed cost is coming down because the fixed cost number is constant.

Professor M Suresh Babu: Yeah. Production is.

Professor G. Venkatesh: Not increasing the production function, so it is a $\frac{1}{x}$, kind of function.

Professor M Suresh Babu: Yes.

Professor G. Venkatesh: $\frac{1}{x}$ kind of function.

Professor M Suresh Babu: Yes.

Professor G. Venkatesh: $\frac{1}{x}$

Professor M Suresh Babu: Yes.

Professor G. Venkatesh: So, that is why you are seeing this curve, which is like this $\frac{1}{x}$ function?

Professor M Suresh Babu: Yes.

Professor G. Venkatesh: Whereas the average variable cost is linearly related to the number of items you produce.

Professor M Suresh Babu: Yeah.

Professor G. Venkatesh: So, it will be a linear curve, increasing line.

Professor M Suresh Babu: It is an increasing function. Yeah.

Professor G. Venkatesh: And so you have a $\frac{1}{x}$ curve.

Professor M Suresh Babu: Yeah.

Professor G. Venkatesh: And you have an x. So, you have $\alpha + B_1 x$

Professor M Suresh Babu: Yes.

Professor G. Venkatesh: $\frac{1}{x}$ and so. In addition to it one curve is decreasing one curve is increasing.

Professor M Suresh Babu: Yeah.

Professor G. Venkatesh: So, when you add up you will get something, which will either come and go, like this or like that.

Professor M Suresh Babu: So, and that takes place at a particular point in the production process.

Professor G. Venkatesh: So, as you are getting this kind of curve.

Professor M Suresh Babu: Yeah.

Professor G. Venkatesh: Because initially it is dominated by the fixed cost.

Professor M Suresh Babu: Yeah. And then.

Professor G. Venkatesh: There, it gets dominated by the various variable cost.

Professor M Suresh Babu: Variable cost. So, we have to decide where we should locate our production.

Professor G. Venkatesh: Okay, I understand. This average total cost is a sum of average fixed cost and variable cost.
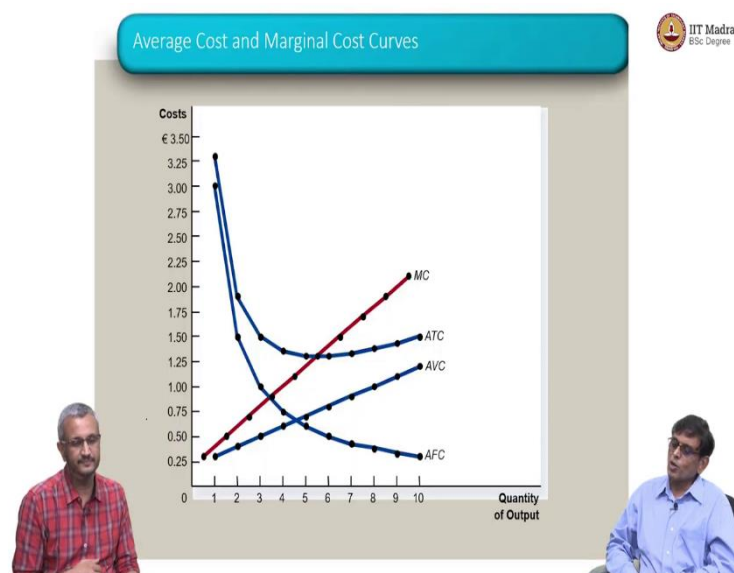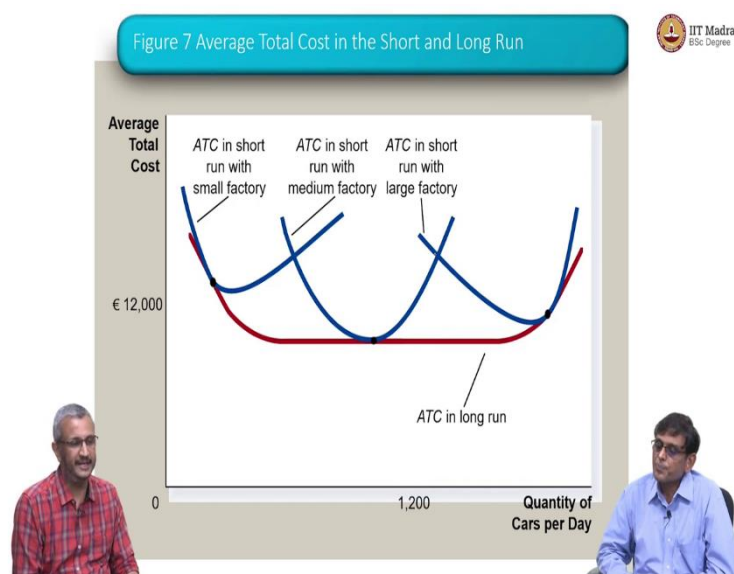
Professor M Suresh Babu: Yeah.

Professor G. Venkatesh: So, it is 1 by x plus x something times 1 by x plus something else times x.

Professor M Suresh Babu: Yes.

Professor G. Venkatesh: That kind of function.

Figure 7 Average Total Cost in the Short and Long Run

Average Cost and Marginal Cost Curves

Professor M Suresh Babu: Now. So, when we plot this, then. So, at a particular point, we need to decide whether we should locate the production or not.

Professor G. Venkatesh: So, in this case, it looks like 4 or 5 or something.

Professor M Suresh Babu: Yeah, look at this region. This region looks pretty okay for me because I can actually take advantage of this falling cost here.

Professor G. Venkatesh: You will get that I may have to draw.

Professor M Suresh Babu: Yeah.

Professor G. Venkatesh: So, this is what you get to see.

Professor M Suresh Babu: Yeah. But, here I can take advantage of this falling curve. But if I move to this region, I will have to face the rising curve.

Professor G. Venkatesh: Rising curve.

Professor M Suresh Babu: So, at a particular point, I have to. So, here at that point, where this marginal cost actually intersects the total costs, I will locate my production.

Professor G. Venkatesh: That is a point. So, that intersecting point is the point where the marginal cost crosses the total cost.

Professor M Suresh Babu: Average. Yeah.

Professor G. Venkatesh: Average total cost curve.

Professor M Suresh Babu: Yes. Beyond that production, I have to really think why I should operate at an increasing part of this cost curve.

Professor G. Venkatesh: Right.

Professor M Suresh Babu: Again, it is flat, and it is slowly increasing.

Professor G. Venkatesh: Okay. I understand.

Professor M Suresh Babu: So…

Professor G. Venkatesh: That is like in this case, it is like 5.
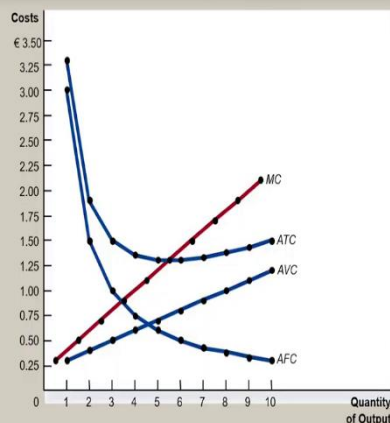
Professor M Suresh Babu: 5 units. Yeah.

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The Various Measures of Cost: Lemonade Shop

Quantity of lemonade glasses (per hour)	Total cost	Fixed cost	Variable cost	Average fixed cost	Average variable cost	Average total cost	Marginal cost
0	€3.00	€3.00	€0.00	–	–	–	
1	3.30	3.00	0.30	€3.00	€0.30	€3.30	€0.30
2	3.80	3.00	0.80	1.50	0.40	1.90	0.50
3	4.50	3.00	1.50	1.00	0.50	1.50	0.70
4	5.40	3.00	2.40	0.75	0.60	1.35	0.90
5	6.50	3.00	3.50	0.60	0.70	1.30	1.10
6	7.80	3.00	4.80	0.50	0.80	1.30	1.30
7	9.30	3.00	6.30	0.43	0.90	1.33	1.50
8	11.00	3.00	8.00	0.38	1.00	1.38	1.70
9	12.90	3.00	9.90	0.33	1.10	1.43	1.90
10	15.00	3.00	12.00	0.30	1.20	1.50	2.10

Average Cost and Marginal Cost Curves

Professor M Suresh Babu: Now, when we go back to the numbers, yeah, the total cost is 6.5 here, the total fixed cost is 3, variable cost is 3.5. The average fixed cost is 0.6, the average variable cost is 0.7, and the average total cost is 1.3. Now, beyond this, average variable cost keeps actually increasing. So, initially, it is high, then it comes down.

Professor G. Venkatesh: Decreasing.

Professor M Suresh Babu: Yeah, then there is a stable region, at 1.3. After that, 1.33, 1.38, 1.43. So, then the U-shaped, you are going to the other part of the U. So, as a rational producer, I will stop production at this part in terms of 5 or 6 units. Beyond that, I would not like to supply to the market. Because from a cost-efficiency point of view, it is not an efficient production region for me. So, that is the advantage of putting this in terms of this formal.

Professor G. Venkatesh: So, the key thing is to maximize utility just like the consumer.

Professor M Suresh Babu: Yeah.

Professor G. Venkatesh: By looking at the consumption basket playing around with various things to consume to maximize their utility.

Professor M Suresh Babu: Yeah.

Professor G. Venkatesh: The producer's job basically is to maximize to minimize cost or to manage cost in the same way.

Professor M Suresh Babu: Yes.

Professor G. Venkatesh: So, they will look at various factors of production and locate.

Professor M Suresh Babu: And locate your quantities in that region.

Professor G. Venkatesh: That region where the cost efficiency is maximum.

Professor M Suresh Babu: Yeah, the cost efficiency is maximum. So, that is a very important decision for a firm, in real examples, a lot of firms get into this euphoria of expansion, and they forget this, they keep expanding. Suddenly, they realize that we have moved to an inefficient region, then they start trimming and cutting.

And that is when we see a lot of workers being retrenching, what was earlier termed as downsizing, but now, we use the term right-sizing of the firm, and all is in terms of getting it back to this region. Why? Because my variable costs are high, let me cut the variable cost a little and bring it to the.

Professor G. Venkatesh: Sell off some assets.

Professor M Suresh Babu: Or sell off some assets and then get into the efficient production region.

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Figure 7 Average Total Cost in the Short and Long Run
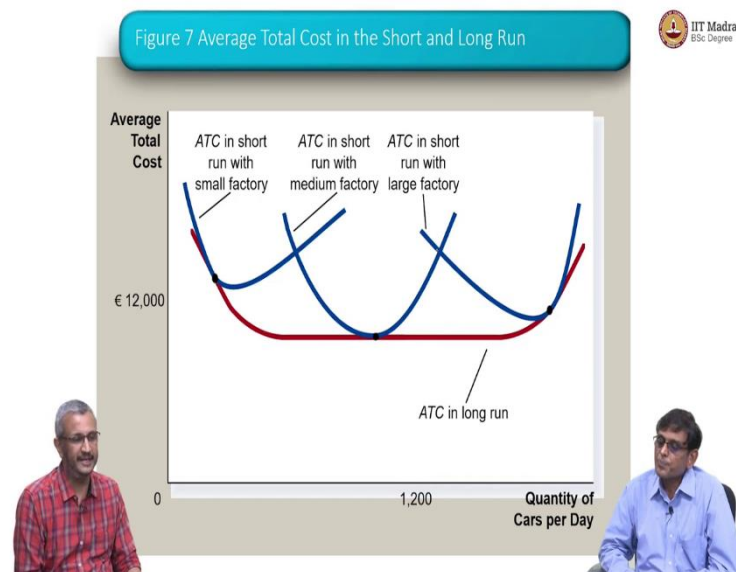
Now, here, we need to bring in two more concepts. That is basically what is this short run and long run that we talk about in production? In the long run, there is no fixed cost, and everything is a variable. That time horizon is called the long run. It could be five years or ten years, perhaps 15 years, depending on the industry that we are talking about.

Professor G. Venkatesh: Because the fixed cost has become so small.

Professor M Suresh Babu: Yeah.

Professor G. Venkatesh: The number of items you produce is so large that by dividing the fixed costs by that large number of items, the fixed cost becomes almost 0.

Professor G. Venkatesh: So, basically, the curve is dominated now by the variable costs at this time.

Professor M Suresh Babu: At this and in the long run.

Professor G. Venkatesh: In the long run. Yeah

Professor M Suresh Babu: In the short run, fixed cost…

Professor G. Venkatesh: Is very dominant.

Professor M Suresh Babu: Is dominant, and you do not have the resources to alter this fixed cost. If you alter the fixed cost, you have to buy another plant and machinery. You do not have the resources also. In the long run, you might have the resources.

Professor G. Venkatesh: Right.

Professor M Suresh Babu: So, if I see that the demand is going to increase in the long run, I might actually set up another plant somewhere else. So, we need to note that there is a difference between the short run and the long run. In the long run everything is variable. In the short run, some things are fixed and some variable.

Now, what we call a long-run cost is nothing but an envelope of the short-run costs. So, there are very different short-run costs. In the long run all these are put into one cost curve because everything is variable in the long run. So, this envelope curve then we have to locate production in this region of envelope curve to be efficient in the long run. This distinction between long run and short run is extremely important because it depends on industry A, B. It also depends on the quantum of fixed cost that the industry needs.

Professor G. Venkatesh: So here you are doing an expansion that is modular. For example, you are saying we will start with a small factory.

Professor M Suresh Babu: Yeah.

Professor G. Venkatesh: And then as the demand goes, we add to the factory.

Professor M Suresh Babu: Move to the medium factory. And then we become a larger factory.

Professor G. Venkatesh: Very large factory. So, that is why we need curves. And now because you have made this decision over capital over a period of time.
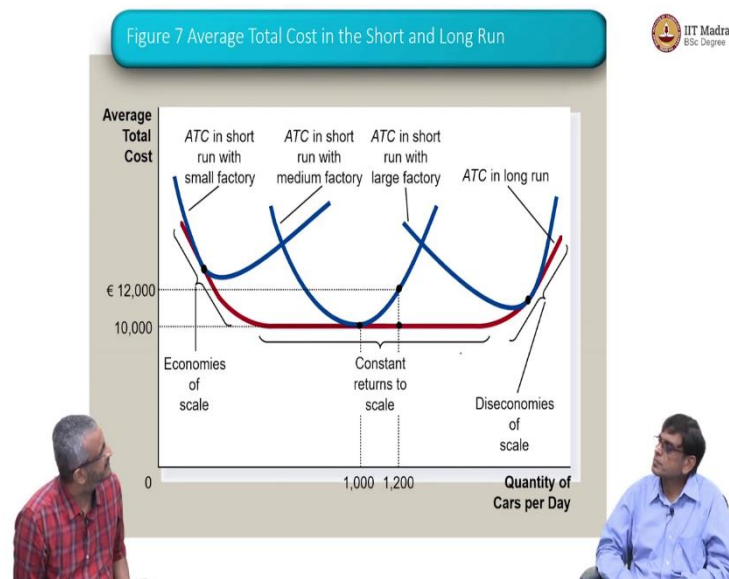
Professor G. Venkatesh: Putting it into one curve.

Professor M Suresh Babu: Which is the envelope curve.

Professor G. Venkatesh: Envelope curve.

Professor M Suresh Babu: So, this is broadly in terms of what we call as an expansion path of a firm.

Figure 7 Average Total Cost in the Short and Long Run

Now, given this, then you can actually bring in three concepts here in terms of production. This region of production is the falling part of the cost curve. We call it as the economies of scale.

Professor G. Venkatesh: That is the first part where it is declining. The cost curve, total cost curve is declining is economy of scale because?

Professor M Suresh Babu: So, economies of scale then is defined in terms of, as and when production increases, the average total cost keeps falling. Average total costs, not the total cost, average total cost keeps falling. So, as and when your production is actually increasing, because of some factors. It could be how you are using your inputs are much efficient, it could be some cost advantages when you expand production, you might buy material in bulk, which could give you some cost advantages.

So, if you are locating at this falling part of this cost curve, then we have economies of scale, a phenomenon where your average total cost keeps falling when your output expands. Then you reach a stage where there is what we call constant returns to scale. That is, for one unit of production, I need one unit of cost one to one relationship. That is fine; firms would like to operate there, even the firms would like to reap this. You cannot keep on reaping this all the time because if you have to keep reaping economies of scale, you have to be highly innovative, and only such firms can be in that part of the cost curve.

Professor G. Venkatesh: Right.

Professor M Suresh Babu: Most of the firms would operate in these constant returns of scale regions. We will come back to it when we talk about the firm's production decisions a little

more. But, this is a very important concept, because firms would not like to move to this diseconomy of scale. What is diseconomies of scale? As and when I increase output, my average total cost keeps increasing by a factor, which is more than this output increase. So, a 2 percent increase in output would result in a 5 percent or a 6 percent increase in cost.

That is not a very comfortable region. So, that is where the firm would like to come back to this constant return to scale kind of a thing. So, production planning then is actually closely related to your cost analysis. And that is what we try to demonstrate here with a very simple to two concepts or costs: fixed and variable costs and average costs and marginal costs.