We talked about isoquants, representing the firm’s technology. We talked about isocosts, representing the firm’s budget. Now we’re ready to put the two together and find the cost-minimizing technique of production in the long run. Remember the long run is where the firm can combine labor and capital in whatever form minimizes the cost of production.

Let’s suppose now, for the sake of argument, that the price of capital is $30.00 per unit; that is, every unit of capital that you hire, you have to pay $30.00 to employ. Let’s suppose that the price of labor is $10.00 a unit, so each worker costs you $10.00. The important thing here is that capital costs three times as much, a unit of capital costs three times as much as a unit of labor. And that’s all we need to say what the slope of the isocost line is. Remember the slope of the isocost line is \(-\text{wage/price of capital}\). In this case, that would be \(-10.00/30.00\), or \(-\frac{1}{3}\).

So here we’ve got an isocost line that has a slope of \(-\frac{1}{3}\). How do we find, in this case, the production strategy that’s going to minimize our firm’s cost of production in the long run? Well, the first thing you need to know is how much output does the firm intend to produce? Let’s suppose our firm is going to produce 12 television sets a week. What combination of labor and capital gives this firm the lowest cost of producing this output? Well, here’s my isocost line and, if I shift it out, I’m spending more money and, if I shift it in, I’m spending less money, but the slope of this line is definitely going to be \(-\frac{1}{3}\). We know that, because we know what the wage is and we know what the price of capital is.

So let’s keep shifting this line in, until we can just barely afford a combination of labor and capital that will allow us to produce 12 television sets. Well, is that combination going to be two workers and six units of capital? And the answer is no, because we could shift the isocost line in further and still be able to afford some combinations on the line. So keep shifting. Will that combination be 1, 2, 3, 4 workers and 1, 2, 3 units of capital? The answer is no, because you can still see the green line down here below. The green line is still there, which means there are combinations of labor and capital that are still less expensive. So finally, if we shift this curve carefully down and we keep the slope at \(-\frac{1}{3}\), we finally wind up with a point where we are just barely touching this isoquant. We have shifted the isocost line so close to the origin that we are just touching the one remaining point on the isoquant, and that is the combination 1, 2, 3, 4, 5, 6 workers and two units of capital. That’s the last combination that we’re going to touch. If we move the isocost line anymore, notice now the isoquant lies completely above it. There are no combinations that are feasible if we’re spending less money. If we’re spending less, we’re not going to be able to touch any point on the isoquant. But if we spend just this amount right here and employ six workers and two units of capital, this is the minimum cost of producing 12 television sets.

Now notice there are a lot of other combinations that are possible for producing 12 television sets, but those combinations all cost more money. How can you tell, by looking at this graph, that these combinations all cost more than this particular combination that touches the isocost line? How can you tell by looking? You can tell because all of these dots lie strictly above the isocost line. In order to get to them, we’d have to shift the isocost line outwards, and that means spending more money on labor and capital. However, if we shift down to this point right here, we find the cost-minimizing technique is the last dot that we touch before we lose contact with that isoquant. So look for the point where the isocost line is tangent to the isoquant. Look for the point where the isocost line just touches the isoquant that represents your target output. That’s the cost-minimizing technique.

In this case, the cost-minimizing technique involves six workers and two units of capital. What is the total cost? Why don’t you take a break and calculate that?
All right, total cost is going to be the wage, $10.00, times six workers is $60.00, plus the cost of capital, which is $30.00 per tool times two units of capital. That’s another $60.00. 60 + 60 = 120. That’s the total cost of production.

Now, if you wanted to prove to yourself that this was the minimum cost of production, you could try calculating the total cost with some of these other combinations. For instance, if you use 12 workers and one unit of capital, what’s the total cost going to be? Take a break and calculate that. 12 workers times $10.00 per worker is 120, plus $30.00 for a unit of capital is 150. So, as our graph points out, this dot is more expensive than this one. This combination of labor and capital is more expensive or more costly than this combination. You can, if you want to convince yourself, do the same analysis for this dot and this dot. All of them involve higher expenditure to produce the same 12 television sets.
Now, it’s important for you to know that the cost-minimizing technique depends completely on the relative price of labor and capital. Suppose the relative price of labor and capital, instead of being 30 to 10, or in this case, a slope of -1/3, suppose we have the price of labor being, let’s say, $30.00 per worker and the price of capital being $40.00? Well, in that case the slope of the line is going to be -$30.00/$40.00 = -3/4. The line is going to be steeper in this case.

Well, in this case, if we pull the line backwards, we’re going to lose touch with our isoquant, we’re going to drop below it, but not until we’ve touched this point right here. With the slope of -3/4, the cost-minimizing technique is going to involve 1, 2, 3, 4 workers and 1, 2, 3 units of capital. Notice that as the wage rises and the price of capital falls relative to the wage, as the isocost line gets steeper, because labor is getting more expensive, notice what happens is this: the firm finds that it’s cost-minimizing to use less labor, because labor is getting more expensive, and more capital, because capital is, in relative terms, getting less expensive. As the isocost line gets steeper, the firm moves a long the isoquant to find a new cost-minimizing technique. If labor got even more expensive, we might see the firm using an even more capital-intensive technique.

The rule is this: when the price of labor increase, the firm minimizes its costs by using less labor and more capital. When the price of capital increases, the firm minimizes its costs by using more labor and less capital. The firm always substitutes, as long as substitution is possible, the firm always substitutes in the direction of the factor that’s becoming relatively less expensive.

Now, let’s go back to our original situation. Labor costs $10.00 per worker and capital costs $30.00 per machine. Let’s suppose now that our firm wants to increase its output. It wants to increase its output from 12 television sets a week to 24 television sets a week. Now notice something: if we were in the short run, when capital is fixed, where in this picture would the firm have to go to increase output to 24 televisions? Find the place in this diagram where the firm would be producing, that is, find the combination of labor and capital that the firm would have to use in the short run. The answer is if capital is fixed, the firm is only going to have two units of capital. If it started at this point with two units of capital and six units of labor, now it has to go over to this point here with two units of capital and 12 units of labor. Now, that’s going to be expensive. We’ve got to shift this cost line all the way out here until it passes through that particular point, 12 workers, two units of capital. How much does that cost? Take a moment and calculate that.

12 workers is $120.00, two units of capital is $60.00, for a grand total of $180.00 to produce those 24 television sets. Is that correct? 12 workers times $10.00 a piece, 120, plus 60 is 180. That’s right. However, if this firm is careful, they’ll be able to substitute in the long run; that is, well, I don’t mean careful, I mean if they have more options, that’s what I mean. If, in the long run, the firm isn’t limited to having two units of capital, but can choose any combination of labor and capital that they want, what will they do? The answer is they'll use more capital and less labor. How can you tell? You can tell, because if you look at this particular isocost line, you can see that there’s part of the isoquant for 24 televisions that lies below it. This firm can economize by shifting the curve in and finding a combination of labor and capital that's tangent to the curve; that is, by shifting the isocost line in and finding another point that touches the isocost line, but is still on the isoquant, the firm can lower its costs. In the long run, once the firm is able to buy more capital, it can then use more capital and less labor to produce the desired number of television sets. In the long run therefore, substitution becomes possible and costs will be lower.

Well, we’ve covered a lot in this lecture. Let me go back and quickly recap the main points. The first point is that the firm minimizes its cost to production by finding the point where the target isoquant is tangent to the isocost line. It’s at that point that you’ve shifted the isocost line in as close to the origin as you can get it. It’s at that point that you’ve got costs at the minimum you can possibly attain.

The second point is if relative price of labor and capital changes, the firm will move along the isoquant to keep its costs at a minimum. If the price of labor increases and the price of capital falls, the firm will move up the isoquant, using a more capital-intensive technique. The firm will always move the technique of production in the direction of using more of the factor whose relative price has fallen. So when labor gets very cheap, the firm uses the labor-intensive technique. When
capital gets relatively cheap, the firm uses a capital-intensive technique. The firm always operates at a point where the isoquant is tangent to the isocost line, and that point will depend on the relative price of labor and capital.

Finally, the third point from this lecture is if the firm wants to increase its output, then, in the short run it's going to have a higher cost, because it can't adjust its fixed input. If capital is the fixed input, the firm has to go all the way out to this point that use two units of capital, that is, if two units is the fixed amount of capital. In the long run, however, the firm can move the isocost line inward and substitute and pick a different point on the isoquant. In the long run, the firm has the flexibility to combine labor and capital in whatever combination minimizes costs.

So, this is the first important thing to know about the long run. In the long run, the firm can combine labor and capital, in order to minimize costs. And therefore the cost of production in the long run of any particular quantity of television sets will be lower in the long run than it is in the short run when some of the inputs are fixed.