[MUSIC]
Hi, Professor Navarro here.
In this fourth lecture we're going to
unlock some of
the mysteries of the supply curve and so
called production theory.
In this lecture there are a number of very
important ideas that we want to dcome to
grips with.
Such as the difference between short run
and long run costs and
the critical concepts of marginal cost and
the law of diminishing returns.
I will also introduce you to a very
powerful concept known as economies
of scale as we examine the various
possible shapes of cost curves.
And the important difference between
economic versus accounting profits.
[MUSIC]
>> Listen to the sound.
[NOISE]
Can you identify it?
What is it?
If you guessed them shaking a can of nuts
and bolts, you're right.
It's what this lecture is about.
The nuts and bolts of supply and
production theory.
In fact, to at least some of you, this
lesson is going to seem like an
unending stream of dry definitions
destined to be
forgotten 16 nanoseconds after you've
finished your final exam.
But let me say two things about that.
First, the definitions and concepts we
will learn
in this lesson are indeed nuts and bolts.
But we will need them to hold together a
great
many of the real-world microeconomics
applications that we'll soon follow.
So ignore them at your own peril.
Second, even though much of this material
is of a nuts and bolts nature.
I also believe that even this material can
be made
relevant to your own personal and
professional experiences.
Let me try to start proving that with this
admittedly somewhat goofy scenario.
Suppose then, that tomorrow morning you
wake up and find yourself as the
main character in a Steven Spielberg movie
called Back To The Business Future.
You're a refugee from the new millennium,
circa 2,000 AD.
And you find yourself smack dab in the
middle of 1972
shortly before the OPEC oil cartel slapped
an embargo on the American economy.
Your only possessions besides the now
quite out of style clothes on your back.
Are the design and engineering blueprints
of a highlight energy efficient
automobile, blueprints that your mad
scientist buddy stuffed in your hands.
Just before he accidentally catapulted you
back
into one of the worst decades in American
economic history.
Some friend, huh?
Now to round out this plot let's assume
that the only
way you can save the planet from a
rapacious foreign cartel.
And also get back home to your family and
friends, is
to make a few million bucks producing
these energy efficient cars.
How do you do it?
Well, the first thing you have to settle
upon is your recipe for producing the car.
Economics, we call this the production
function.
Algebraically, it looks like this.
Q is your output and K, L and R are your
factor inputs.
Specifically, Q is the quantity of cars
you want to produce.
K is the capital or plant and equipment
that you will need
for the production L is the number of
employees or quantity of labor.
And R is a catch-all term for things like
raw materials and energy.
As for that F term, that is the state of
the current technology.
The more advanced the technology, the more
output you'll be able
to produce for a given mix of labor,
capital and resource inputs.
In technical terms, the production
function specifies
the maximum output that can be produced
with a given quantity of inputs, for

a given state of engineering and technical knowledge.
So, in order to make your millions, what combination of inputs are you going to choose?
And by implication,
what would be the size of your automobile plant?
Those are two questions we will be able at least partly answer later in this lesson.
But before we do that, let's make a further distinction,
the distinction between the short run and the long run.
To illustrate the short run suppose the factory for your energy efficient
auto is already up and running and producing 10,000 cars a year.
Further suppose that
the Organization of Petroleum Exporting Countries, the
OPEC cartel slaps an embargo on the U.S. and quadruples the price of oil, just as it did in 1973 and 1974.
At this point, demand starts to increase dramatically for your cars
as consumers seek to substitute your gas miser for their gas guzzlers.
What do you do?
In the short run, you add two more shifts, hire more workers and use more energy and raw materials as you try to run
your plant around the clock to meet increased demand.
In fact, in the short run, this is your only option.
Because it would take over a year to build a new factory.
And that's the definition of the short run.
The period in, which firms can adjust production
only by changing variable factors such as materials and
labor but cannot change fixed factors such as capital.
In contrast, the long run is a period sufficiently long enough so
that all factors in the production
function, including capital can be adjusted.
In this case, it is the time it would take for
you to expand your existing factory or build a new one.
This distinction between the short and long run is important
in production theory because each period has its own kind
of cost analysis.

[MUSIC]
Let's start then with short run cost
analysis by taking
a look at this table detailing auto
production at your factory.
You can think of this table as the short
run cost curve
forest and each of the columns in the
table as its trees.
What we're going to now is systematically
look at each of the
trees so that later on we don't get lost
in this forest.
The first column is the quantity of cars
your factory
can produce in thousands.
The second column simply represents your
firm's fixed costs.
These fixed costs are sometimes called
overhead or sunk costs.
And fixed costs are those costs that do
not change
with the level of output, examples of such
fixed costs include
rent, interest on the bonds you issued to
get money to
build your factory, insurance premiums,
the salaries of top management and
so on.
Note that the first five rows in this
column are all equal to the same thing,
50.
What do you think the values will be for
the remaining question marks?
That's right, 50.
Fixed costs are fixed, and that's the
point.
Now, let's say I had two more columns,
total variable cost, and total cost.
Variable costs are simply those costs that
change with the level of output.
For example, when you increase production
to meet demand
you have to pay for more raw materials and
fuel.
You also have to pay more in wages
to cover the increased overtime and
additional workers.
Those are all variable costs.
Now in the table note that total cost is
simply variable cost plus fixed cost.
Take a minute now to fill in the question
marks.
Does your table look like this?
Now let's add a fifth column.
That for the marginal cost.
And note here you've already encountered
this marginal
concept when we talked about the consumers
marginal utility.
The additional utility that a consumer
gets
from a one unit increase in consumption.
Knowing that, how would you define the
firm's marginal cost?
That's right, the marginal cost is simply
be additional cost
incurred in producing one extra unit of
output.Thus, in the
table when we increase output from say 10
to 11,
we've observe the total cost increase is
from 150 to 156.
In this case, the marginal cost of that
additional unit of production is six.
Take a minute now to fill in the question
marks in the rest of the table.
Does your table look like this?
If not, work through your calculations
again.
As for these values, the astute student
will notice an interesting pattern.
While fix costs stay the same in column
two, and both
variable and total costs rise, marginal
costs first fall and then rise.
How would you explain this pattern?
The answer lies in the The Law of
Diminishing Returns.
What is this law?
You probably figured that out knowing what
you know about the Law of
Diminishing Marginal Utility that we
introduced
in the last lecture on consumer theory.
In the context of production theory, we
have to first remember that
in the short run, capital is fixed but
factors like labor are variable.
In such a situation, adding more
workers means that each additional unit of
labor has less capital to work with.
At some point then, the extra or marginal
product of each additional worker must
begin to decrease.
That's the law of diminishing returns.
By the way, knowing what you now know

about the concepts
of marginal utility and marginal cost, how
would you define marginal product?
The marginal product of an input such as
labor is the extra output added
by one extra unit of the input, holding
other things such as capital constant.
Now let's note that the marginal product
can't keep rising forever.
For example, in your car factory, as you
add more and more workers, the assembly
line
starts to get too crowded and workers have
to wait in line to use the machines.
Thus, at some point the total product or
total output
keeps increasing but begins to do so at a
decreasing rate.
To demonstrate this, take a look at this
table.
It shows the total product that can be
produced
for different inputs of labor holding
other things constant.
After you fill in the question marks in
the
table, try to graft a relationship of both
the
total product of labor as well as the
marginal
product of labor, keeping labor on the
horizontal axis.
Do your graphs look like this?
Note that as total product rises, it does
so at a decreasing rate, as indicated
by the smaller and smaller incremenets in
the dark gray squares in the left-hand
corner.
Note, also, how this translates to a
falling marginal product curve.
It should be clear from this discussion
that a rising marginal
cost curve must follow directly from a
falling marginal product curve.
Moreover, the shapes of both curves are
attributable to the law of diminishing
returns.

[MUSIC]
Here is a red flag.
Are used these flags sometimes when I really, really,
really want to make an important point, here it is.
The concept of marginal cost is one of the most essential in microeconomics.
As we shall learn in a later chapter competitive firms will produce
at alevel where the price of the product equals their marginal cost.
And in that same lesson,
we'll also learn that the supply curves is actually that portion
of the marginal cost curve above the average variable cost curve.
So perhaps you can see how this lecture provides you
with a lot of valuable nuts and bolts for future use.
[SOUND].
Now let's complete our short run cost analysis table
by introducing the final three columns in our table.
For average fixed cost, average variable cost and average total cost.
These columns are simply derived by calculating averages using
columns one through four and the formulas in the table.
Using the formulas, try filling in the question marks now.
The interesting thing about these three
[SOUND]
columns is the graph we can draw from them
and our now old friend, marginal cost.
Look at this graph carefully, and try to answer these questions.
Why does the AFC curve slope downward and approach zero on
the horizontal axis, while the AVC curve approaches the ATC curve.
The AFC curve approaches zero because as a firm's output increases, it spreads its
fixed costs over a larger number of units.
So average fixed costs must fall.
For the same reason the AVC curve
must approach the ATC curve as output increases.
These are important insights in business, because the name of the
game is often to spread your fixed costs over as many units
as possible.
Now, here's a trickier question.
We know why the ATC, AVC, and MC curves slope first down and then up.
It's the law of diminishing returns, remember?
But why the does the MC curve intersect both the AVC and AC curves at their minimums?
Take a minute to try and write down your answer.
The answer lies in these formulas, if MC is greater
than ATC, then the ATC must be rising and vise versa.
Think of it this way.
If the production of an additional unit has
a marginal cost greater than the average cost.
Then production of that unit must drive the
[SOUND]
average up, and conversely.
Thus, it must be that only when MC equals
ATC that the ATC is at its lowest point.
This is a critical relationship.
It means that a firm searching for the
lowest average cost of production
should look for the level of output at
which marginal cost equals average cost.
To better understand this relationship,
study the curves in this figure for a moment.
Note that there is a small range, Area B, where
average cost is falling and average variable cost is rising.
Now here's the punchline.
[SOUND]
When marginal cost is coupled with the concept of
marginal revenue, that we will introduce in the next
lecture The firm is able to determine if it
is profitable to expand or contract its production level.
In fact, the analysis in the next several
lectures centers on these types of
marginal calculations.
That's why learning these nuts and bolts

concepts now is so important.
[SOUND]
And this completes our exploration of
short run cost analysis.

[MUSIC]
Now, let's turn to the long run.
Recall that the long run is when all
factors are variable, including capital.
Let's put this in plain terms by going
back
to your back to the business future auto
plan.
Remember that in the beginning, we assume
that
you started off with a relatively small
plan.
Then, as demand expanded, you built more
plant capacity.
Now suppose that this pattern kept
repeating itself and that you kept
building larger and larger plants.
What do you think would happen to
your firm's average cost as plant scale
increased?
It's a good question, but it's also a
trick
question because there are a number of
possible answers.
This figure represents the first answer.
It illustrates an important mantra that I
want you to remember.
The long run average cost curve is the
envelope of the short run average cost
curves.
Think of this envelope concept this way,
for
any given plant scale, two things are
certain.
Capital inputs are fixed in the short run,
and there is
a point on the ATC curve where average
cost is minimized.
Now if you built a bigger plant output
will increase
and there will be another short run ATC
curve created.
which point on this bumpy planning curve,
shows the least unit cost attainable for
any output when the
farm has had time to make all desired
changes in plant size.
Now if the number for possible plant sizes
if very
large, the long run average cost curve
approximates a smooth curve.
Now there's something very important I
want you
to notice about this long run cost curve.
It's obviously broad U shape.
How how would you interpret this shape?
They u shape of the long run average cost
curve suggests that at least up until
point q star, the larger and larger plant
size will mean a lower and lower unit
cost.
However, beyond q star, successively
larger
plants mean higher average total costs.
The reason for this is not the law of
diminishing
returns, which explained our U shaped
short run average cost curves.
In the long run, the law of diminishing
returns does not apply, because all
factors are variable.
Instead, the explanation lies in
understanding this key conceptual triad.
Economies of scale, diseconomies of scale
and constant returns to scale.
Economies of scale exist when the per unit
output cost of all inputs decreases as
output increases.
Economies of scale to may be traced to
labour specialization,
managerial specialization, efficient
capital, by
products and other such factors.
Increased labour specialization means
dividing and
subdividing jobs as plant size increases.
Instead of performing five or six jobs, a
worker can focus on one.
For example, in a small plant, a skilled
machinist might spend
half the time performing unskilled tasks
leading to higher production costs.
Greater specialization also eliminates the
loss of
time that occurs when workers shift
between jobs.
With managerial specialization, a
supervisor who can handle
20 workers will be under-used in a small
plant.
As well as sales specialist who may have
to divide his or
her time between other managerial
functions,
such as marketing, personnel, and finance.
Larger plant size also facilitates the
most efficient capital use.

For example, in the auto industry, the most efficient
production method involves robotics and sophisticated assembly line equipment.
But effective use of such machinery and equipment
requires an output of at least 200,000 cars.
Larger scale production also allows better use of by-products.
For example, a large meat packing plant will also make glue, fertilizer,
and pharmaceuticals from animal remains which
would otherwise be discarded by smaller producers.
Finally, there are other factors
such as design, development, and certain other start
up costs that must be incurred irrespective of sales.
These costs per unit decline as output increases.

[MUSIC]
An excellent example of how the concept of economies of scale enters into important policy debates, is offered by the case of the B2 or Stealth Bomber.
The Pentagon originally wanted to build 132 of the planes at a cost of $580 million per plane.
But the secretary of defense slashed the Pentagon's request to only 75 bombers.
The result?
The cost per plane soared to over $800 million, due to the loss of scale economies.
Now, just as a firm can benefit from economies of scale, so too can it be harmed by diseconomies of scale.
Such diseconomies are characterized by higher unit costs as plant size increases beyond a certain point.
In our figure, Q*.
The main problem causing dis-economies of scale lies with managerial problems, in efficiently controlling and coordinating a firm's operations as it becomes a large scale producer.
At some point, a plant just gets too big for effective management.
At the same, in massive production facilities, workers may begin to feel alienated from their jobs and efficiency may suffer.
Now take a look at this key figure.
It shows four very different possible long-run cost curves for a given industry.
The first graph shows the broad U-shaped curve we observed earlier.
But now, in the second graph, note that the U-shape is much more pronounced.
Note also the flat segment in the third graph.
And finally, note the downward slope in the fourth graph.
How would you explain the shapes of each of these curves?
Let's start with the second graph.
Here the narrow and steep U-shape indicates that economies of scale are exhausted quickly, so that minimum unit cost will be encountered in a relatively low output.
Typical profile of an industry characterized by this kind of curve is numerous sellers in healthy competition.
Examples include many retail trades and some types of farming, as well as certain types of light manufacturing, such as baking, clothing, and shoes.
In such industries, a particular level of consumer demand will support a large number of relatively small producers.
In this graph, rather than a smooth U, there is a long flat spot in the middle of the curve, over which unit costs do not vary with size.
This is the case of constant returns to scale and it characterizes many American industries.
For example,
[SOUND]
during the 1980s there were a lot mergers in the commercial banking industry, at the time most analysts that unit costs would all dramatically.
After all, banks could close some of their branches in overlapping markets, and combine support services such as computer processing, advertising, auditing and legal work.
However, studies found that the mergers did not significantly reduce costs.
One possible explanation is constant returns to scale over a broad spectrum of output.
Now take a look at the fourth graph.
This is one of the most famous in economics, because it is the signature of what is called a natural monopoly.
The idea here, is that unit costs steadily fall, so that we have increasing returns to scale over the relevant range of output.
As we shall see more fully in the next lecture, this means that over time bigger producers will drive out smaller producers, until there

is only one producer left, the infamous monopolous.
As we shall also see, the result of this so called market failure is that price will be set too high, and output too low for market efficiency.
And government regulation may be warranted.
Examples of regulated natural monopolies include rail roads and cable TV.
And the distribution of electricity, gas, and local telephone service.
The case of natural monopoly allows us to introduce yet another important concept in production theory.
That of minimum efficient scale.
This is defined as the smallest level of output at which a firm can minimize long-run average costs.
In our constant returns to scale figure, this point is reached at Q1, however, note that because of the extended range of constant returns to scale, relatively large and relatively small firms can coexist and be equally viable.
This, in fact, is the case in industries such as apparel, food processing, furniture, wood products, and small appliances.
In contrast, in the case of natural monopolies, like the rail roads and utilities, small firms cannot realize the MES, the minimum efficiency scale.
So there is only one seller.
At the same time, a large minimum efficient scale can also give rise to another type of industry structure known as oligopoly.
An oligopolistic industry is characterized by a small number of large sellers.
Examples include automobiles, aluminum, steel, and cigarettes.
The broader point here is that the shape of an industry's long run average cost curve, has an enormous influence on the structure of that industry.
Will it be competitive, oligopolistic or monopolistic?
As we shall see in subsequent lectures, these different market structures in turn determine the conduct of the firms and therefore the performance of the market.

[MUSIC]
This completes our discussion of short and long run cost analysis.
Now there are just two more tasks we have to complete.
Talk about the difference between economic and accounting profits
and clean up a few things about the supply curve.
Let's start with the supply curve.
In the next lesson, I'll show you how to derive that curve from the upward sloping marginal cost curve.
However, for now, let's just
point out several common traits that the supply curve has with
the demand curve that we learned about in the last lecture.
First, just as there is a law of demand, there is a law of supply.
When the price of a good increases,
the quantity of that good supplied will increase.
This means of course that the supply curve is upward sloping.
Second, just as there is a price elasticity
of demand, there is a price elasticity of supply.
Knowing what you know about demand elasticity, try writing the supply elasticity formula.
Did you get it right?
The price elasticity of supply is simply the percent change
in quantity supplied divided by the percent change in price.
Just as with the elasticity of demand, the most important determinant of
the elasticity of supply is the number of substitutes for the good.
If substitution is easy, supply will be elastic.
If substitution is difficult, supply will be inelastic.
Try drawing an elastic, inelastic and unit elastic supply curve.
The curves look like this.
Now to finish this lesson, let's spend
a few minutes talking about the important difference
between how an economist measures a firm's cost
and profits and how an accountant measures them.
In this regard, an economist as opposed to an accountant,
will always count not only explicit but implicit cost as well.
In business, explicit costs are your monetary
payments to outsiders for things like labor,
materials, fuel, transportation and power.
In contrast, your implicit costs represent the money payments you could
have earned by employing your own resources in their best alternative use.
This distinction sheds further light on the concept of
opportunity costs that we introduced in an earlier lecture.
The opportunity costs of the decision includes all of it's consequences.
Whether they reflect explicitly monetary transactions or not.
For example, the immediate dollar cost of going to a movie instead
of reading your economics textbook is the price of the movie ticket.
However, the opportunity cost also includes the possibility of gaining a
better understanding of macroeconomics and therefore becoming more successful in business.
To illustrate, explicit, implicit,
and opportunity costs, try your hand at this example.
Suppose both you and your spouse earn after tax salaries of
$45,000 a year as sales representatives for a hospital equipment distributor.
But you want to do better.
So you both quit your jobs to open your own business.
A health food juice bar called Juice Me Up Scotty.
For your start-up capital, you borrowed $20,000 from the bank at 10% interest.
You kick in another $30,000 of your own savings that had been earning you $1,500 annually in interest income from your portfolio bond investments.
You also kick out the tenant in the storefront that
you own so you can use it for your own business.

A tenant, by the way, who is paying you
$800 in rent per month.
Now take a look at this income statement
that your
accountant has prepared for your business
after a year of operation.
Items two, three and four represent your
cost
of goods sold, which are basically your
variable costs.
These total 97,000 dollars and include
employee compensation, operating
costs such as utilities, and materials
like the 400 pounds of carrots and 1,000
bushels of oranges that you've juiced.
Items six, seven, and eight represent your
fixed costs
since, in the short-run, these costs can't
be changed.
A total, another $18,000, and include
things like selling and administrative
costs, rent,
which in your case is zero because you own
the building, and appreciation.
This last category is an interesting one.
When your company buys, say a cash
register for your
store, it may have an estimated useful
life of ten years.
So each year in effect, you use up a
portion of that machine.
Appreciation is a way of measuring the
annual cost
of the each capital input that your
company owns.
Now, subtracting net sales form operating
expenses
yields a net operating income of a
$140,000.
From this you have to subtract the taxes
you pay to
the government, as well as the interest
payments on your loan.
This yields an accounting profit or net
income before taxes of $135,000 and
an after tax accounting profit of $90,450,
which you could either pay out as
dividends if you
had shareholders, or count is retained
earnings for the firm.
And that looks pretty good
for a year's work.
But what implicit costs have you ignored?
Try calculating them and then subtract
them from
the accounting profit to get your true
economic profit.
Here's my calculation.
It shows that, at least in this case, you
wound
up actually being worse off by going into
business for yourself.
By providing your own financial capital
you gave up $1,500 in forgone interest.
By kicking out your tenant you gave up
$9,600 in annual rent.
And then, of course, there's the $90,000
in
after tax salaries that you and your
spouse
gave up to work for yourselves.
Subtracting all these implicit costs from
the accounting profit you wind up for all
your blood, sweat and carrot juice with a
negative economic profit of $10,650.
That's not very good.
In fact, people make mistakes like this
all the time in
both their personal and professional lives
because they base important decisions
on accounting rather than economic
profits.
So please be careful and always consider
your opportunity cost when you make a
decision.
[MUSIC].