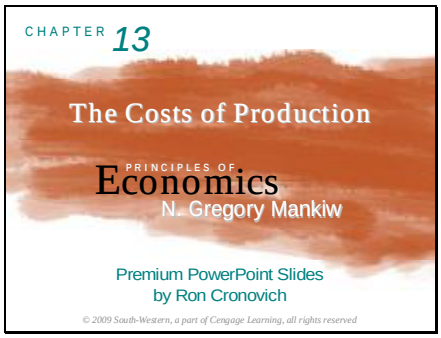
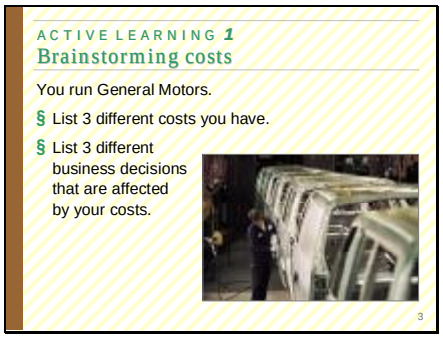
PowerPoint Lecture Notes for Chapter 13:
The Costs of Production
***Principles of Economics* 5th edition, by N. Gregory Mankiw**
Premium PowerPoint Slides by Ron Cronovich



This chapter is very technical and full of definitions and graphs. Most of the material is not very analytical. But it may be harder for some students to see the relevance of this material.

So, this PowerPoint begins with a short brainstorming activity on the next slide. This activity asks students to think of several costs that a real-world firm actually faces and the kinds of decisions that are affected by these costs. Having realized that costs are important to business decisions, students should be more motivated to learn the concepts in this chapter.

It might also be worthwhile to point out that material in this chapter provides the foundation for the following four chapters. In those four chapters, we will see how firms in different market structures use the cost concepts introduced here to make decisions about how much stuff to produce, what price to charge, and so forth. Learning that material will be much easier for students if they have a good grasp of the material in this chapter.



SUGGESTION: Show the slide and give students a few quiet moments to formulate their answers. Better yet, have them work in pairs. Then, ask for volunteers to share their answers. Total time for this activity: 5-15 minutes.

The literature on teaching and learning indicates that brainstorming activities like this are very effective. This activity will motivate the chapter, engage students, and prime them for learning the cost concepts that follow.

Examples of GM's costs: Wages & benefits, cost of intermediate inputs (like engine parts, tires, etc), rent, advertising (though advertising is not a production cost).

Examples of decisions affected by costs: How many workers to hire, what size factory to build, what price to charge, how many of each type of vehicle to produce.

If you wish, you can type (concise versions of) students' responses on a PowerPoint slide as students share their responses. As long as you can type reasonably well, this is easy to do. Before class, insert two slides following this one. Title the first slide "GM's costs" and the second one "Decisions affected by GM's costs". During your class presentation, when you get to this point, hit the "ESC" key to stop your presentation and go into edit mode. Make sure the main editing window is big enough for students to see. Type brief versions of students' responses as they share them with the class. When you are done, resume the presentation from the current slide.

What if a student gives an incorrect response? You can explain why it's incorrect. Or, add it to the list; after you have completed the list, ask the class to look it over and to verify that each item really belongs on the list. Get other students to identify the incorrect answer and explain why it's incorrect.

In this chapter, look for the answers to these questions:

- What is a production function? What is marginal product? How are they related?
- What are the various costs, and how are they related to each other and to output?
- How are costs different in the short run vs. the long run?
- What are "economies of scale"?

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Total Revenue, Total Cost, Profit

- We assume that the firm's goal is to maximize profit.

Profit = **Total revenue** – **Total cost**

- **Total revenue**: the amount a firm receives from the sale of its output
- **Total cost**: the market value of the inputs a firm uses in production

Costs: Explicit vs. Implicit

- **Explicit costs** require an outlay of money, *e.g.*, paying wages to workers.
- **Implicit costs** do not require a cash outlay, *e.g.*, the opportunity cost of the owner's time.
- Remember one of the Ten Principles:
  The cost of something is what you give up to get it.
- This is true whether the costs are implicit or explicit. Both matter for firms' decisions.

Explicit vs. Implicit Costs: An Example

You need $100,000 to start your business. The interest rate is 5%.

- Case 1: borrow $100,000
  - explicit cost = $5000 interest on loan
- Case 2: use $40,000 of your savings, borrow the other $60,000
  - explicit cost = $3000 (5%) interest on the loan
  - implicit cost = $2000 (5%) *foregone* interest you could have earned on your $40,000.

In both cases, total (exp + imp) costs are $5000.

In Case 2, the foregone interest is the interest you could have earned on your savings. It is an opportunity cost.

This example shows that an important implicit cost is the cost of capital, the foregone returns you could have earned had you used your savings to buy bonds or other assets instead of investing them in your business.

The hope is that students will see that what really matters to them is not just the explicit costs, but total (implicit + explicit) costs.

Economic Profit vs. Accounting Profit

- **Accounting profit**
  = total revenue minus total explicit costs
- **Economic profit**
  = total revenue minus total costs (including explicit and implicit costs)
- Accounting profit ignores implicit costs, so it's higher than economic profit.

Accountants keep track of how much money flows into and out of the firm, so they ignore implicit costs.

Economists study the pricing and production decisions of firm, which are affected by implicit as well as explicit costs.

ACTIVE LEARNING 2

Economic profit vs. accounting profit

The equilibrium rent on office space has just increased by $500/month.

Compare the effects on accounting profit and economic profit if

a. you rent your office space
b. you own your office space

ACTIVE LEARNING 2

Answers

The rent on office space increases $500/month.

a. You rent your office space.
Explicit costs increase $500/month.
Accounting profit & economic profit each fall $500/month.

b. You own your office space.
Explicit costs do not change, so accounting profit does not change.
Implicit costs increase $500/month (opp. cost of using your space instead of renting it), so economic profit falls by $500/month.

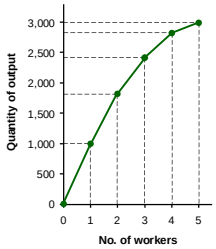
The Production Function

- A **production function** shows the relationship between the quantity of inputs used to produce a good and the quantity of output of that good.
- It can be represented by a table, equation, or graph.
- Example 1:
  - Farmer Jack grows wheat.
  - He has 5 acres of land.
  - He can hire as many workers as he wants.

In the following slides, Example 1 will be used to illustrate the production function, marginal product, and a first look at the costs of production.

Example 1: Farmer Jack's Production Function

L (no. of workers)	*Q* (bushels of wheat)
0	0
1	1000
2	1800
3	2400
4	2800
5	3000



Marginal Product

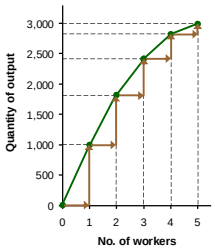
- If Jack hires one more worker, his output rises by the *marginal product of labor*.
- The **marginal product** of any input is the increase in output arising from an additional unit of that input, holding all other inputs constant.
- Notation:
  Δ (delta) = "change in…"
  Examples:
  Δ***Q*** = change in output, Δ***L*** = change in labor
- Marginal product of labor (*MPL*) = $\frac{\Delta Q}{\Delta L}$

EXAMPLE 1: Total & Marginal Product

	L (no. of workers)	***Q*** (bushels of wheat)		*MPL*
	0	0		
Δ***L*** = 1	1	1000	Δ***Q*** = 1000	1000
Δ***L*** = 1	2	1800	Δ***Q*** = 800	800
Δ***L*** = 1	3	2400	Δ***Q*** = 600	600
Δ***L*** = 1	4	2800	Δ***Q*** = 400	400
Δ***L*** = 1	5	3000	Δ***Q*** = 200	200

EXAMPLE 1: MPL = Slope of Prod Function

L (no. of workers)	***Q*** (bushels of wheat)	*MPL*
0	0	
1	1000	1000
2	1800	800
3	2400	600
4	2800	400
5	3000	200



Why MPL Is Important

- Recall one of the Ten Principles:
  Rational people think at the margin.
- When Farmer Jack hires an extra worker,
  - his costs rise by the wage he pays the worker
  - his output rises by *MPL*
- Comparing them helps Jack decide whether he would benefit from hiring the worker.

Why MPL Diminishes

- Farmer Jack's output rises by a smaller and smaller amount for each additional worker. Why?
- As Jack adds workers, the average worker has less land to work with and will be less productive.
- In general, *MPL* diminishes as ***L*** rises whether the fixed input is land or capital (equipment, machines, etc.).
- **Diminishing marginal product**:
  the marginal product of an input declines as the quantity of the input increases (other things equal)

Thinking at the margin helps not only Jack, but all managers in the real world, who make business decisions every day by comparing marginal costs with marginal benefits.

EXAMPLE 1: Farmer Jack's Costs

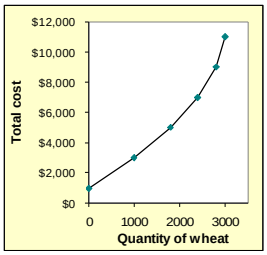
- Farmer Jack must pay $1000 per month for the land, regardless of how much wheat he grows.
- The market wage for a farm worker is $2000 per month.
- So Farmer Jack's costs are related to how much wheat he produces….

EXAMPLE 1: Farmer Jack's Costs

L (no. of workers)	***Q*** (bushels of wheat)	Cost of land	Cost of labor	Total Cost
0	0	$1,000	$0	$1,000
1	1000	$1,000	$2,000	$3,000
2	1800	$1,000	$4,000	$5,000
3	2400	$1,000	$6,000	$7,000
4	2800	$1,000	$8,000	$9,000
5	3000	$1,000	$10,000	$11,000

EXAMPLE 1: Farmer Jack's Total Cost Curve

Q (bushels of wheat)	Total Cost
0	$1,000
1000	$3,000
1800	$5,000
2400	$7,000
2800	$9,000
3000	$11,000



Marginal Cost

- **Marginal Cost** (*MC*) is the increase in Total Cost from producing one more unit:

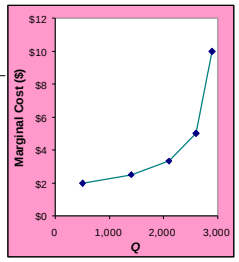
$$MC = \frac{\Delta TC}{\Delta Q}$$

EXAMPLE 1: Total and Marginal Cost

	Q (bushels of wheat)	Total Cost		Marginal Cost (*MC*)
	0	$1,000		
ΔQ = 1000	1000	$3,000	Δ**TC** = $2000	$2.00
ΔQ = 800	1800	$5,000	Δ**TC** = $2000	$2.50
ΔQ = 600	2400	$7,000	Δ**TC** = $2000	$3.33
ΔQ = 400	2800	$9,000	Δ**TC** = $2000	$5.00
ΔQ = 200	3000	$11,000	Δ**TC** = $2000	$10.00

EXAMPLE 1: The Marginal Cost Curve

Q (bushels of wheat)	TC	MC
0	$1,000	
		$2.00
1000	$3,000	
		$2.50
1800	$5,000	
		$3.33
2400	$7,000	
		$5.00
2800	$9,000	
		$10.00
3000	$11,000	



Why MC Is Important

- Farmer Jack is rational and wants to maximize his profit. To increase profit, should he produce more or less wheat?
- To find the answer, Farmer Jack needs to "think at the margin."
- If the cost of additional wheat (*MC*) is less than the revenue he would get from selling it, then Jack's profits rise if he produces more.

In the next chapter, we will learn more about how firms choose Q to maximize their profits.

Fixed and Variable Costs

- **Fixed costs (*FC*)** do not vary with the quantity of output produced.
  - For Farmer Jack, *FC* = $1000 for his land
  - Other examples: cost of equipment, loan payments, rent
- **Variable costs (*VC*)** vary with the quantity produced.
  - For Farmer Jack, *VC* = wages he pays workers
  - Other example: cost of materials
- **Total cost (*TC*)** = *FC* + *VC*

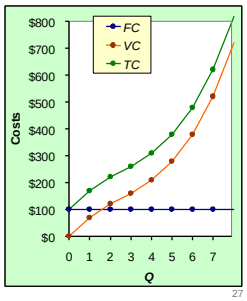
If you did Active Learning 1 and created a class-generated list of General Motors' costs, you might return to that list and ask students which of the costs on their list are fixed and which are variable.

EXAMPLE 2

- Our second example is more general, applies to any type of firm producing any good with any types of inputs.

EXAMPLE 2: Costs

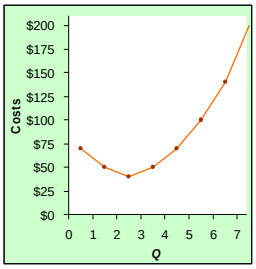
Q	FC	VC	TC
0	$100	$0	$100
1	100	70	170
2	100	120	220
3	100	160	260
4	100	210	310
5	100	280	380
6	100	380	480
7	100	520	620



Point out that the TC curve is parallel to the VC curve but is higher by the amount FC.

EXAMPLE 2: Marginal Cost

Q	TC	MC
0	$100	
1	170	$70
2	220	50
3	260	40
4	310	50
5	380	70
6	480	100
7	620	140



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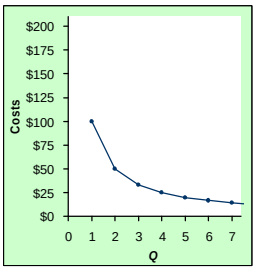
EXAMPLE 2: Average Fixed Cost

Q	FC	AFC
0	$100	n/a
1	100	$100
2	100	50
3	100	33.33
4	100	25
5	100	20
6	100	16.67
7	100	14.29



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Most students quickly grasp the following example.

Suppose FC = $1 million for a factory that produces cars.

If the firm produces Q = 1 car, then AFC = $1 million.

If the firm produces 2 cars, AFC = $500,000.

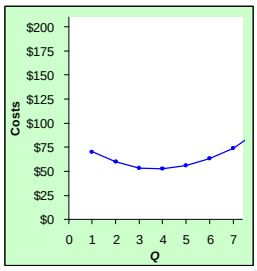
If the firm produces 5 cars, AFC = $200,000.

If the firm produces 100 cars, AFC = $10,000.

The more cars produced at the factory, the smaller is the cost of the factory per car.

EXAMPLE 2: Average Variable Cost

Q	VC	AVC
0	$0	n/a
1	70	$70
2	120	60
3	160	53.33
4	210	52.50
5	280	56.00
6	380	63.33
7	520	74.29



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EXAMPLE 2: Average Total Cost

Q	TC	ATC	AFC	AVC
0	$100	n/a	n/a	n/a
1	170	$170	$100	$70
2	220	110	50	60
3	260	86.67	33.33	53.33
4	310	77.50	25	52.50
5	380	76	20	56.00
6	480	80	16.67	63.33
7	620	88.57	14.29	74.29

Average total cost (*ATC*) equals total cost divided by the quantity of output:

$ATC = TC/Q$

Also,

$ATC = AFC + AVC$

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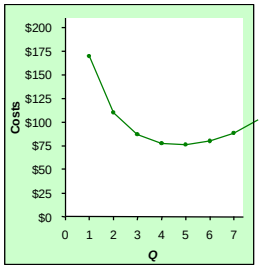
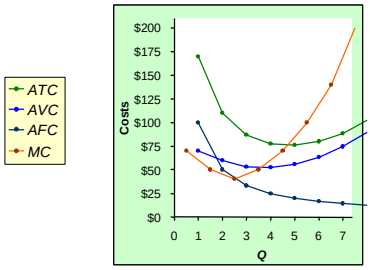
Many students have heard the terms “cost per unit” or “unit cost” in other business courses. ATC means the same thing.

EXAMPLE 2: Average Total Cost

Q	TC	ATC
0	$100	n/a
1	170	$170
2	220	110
3	260	86.67
4	310	77.50
5	380	76
6	480	80
7	620	88.57



EXAMPLE 2: The Various Cost Curves Together



ACTIVE LEARNING 3

Calculating costs

Fill in the blank spaces of this table.

Q	VC	TC	AFC	AVC	ATC	MC
0		$50	*n/a*	*n/a*	*n/a*	$10
1	10			$10	$60.00	
2	30	80				30
3			16.67	20	36.67	
4	100	150	12.50		37.50	
5	150			30		60
6	210	260	8.33	35	43.33	

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ACTIVE LEARNING 3

Answers

First, deduce *FC* = $50 and use *FC* + *VC* = *TC*.

Q	VC	TC	AFC	AVC	ATC	MC
0	$0	$50	*n/a*	*n/a*	*n/a*	$10
1	10	60	$50.00	$10	$60.00	20
2	30	80	25.00	15	40.00	30
3	60	110	16.67	20	36.67	40
4	100	150	12.50	25	37.50	50
5	150	200	10.00	30	40.00	60
6	210	260	8.33	35	43.33	

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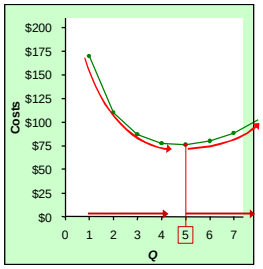
EXAMPLE 2: Why ATC Is Usually U-Shaped

As **Q** rises:

Initially, falling *AFC* pulls *ATC* down.

Eventually, rising *AVC* pulls *ATC* up.

Efficient scale: The quantity that minimizes ATC.



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In this example, the efficient scale is Q=5, where ATC = $76.

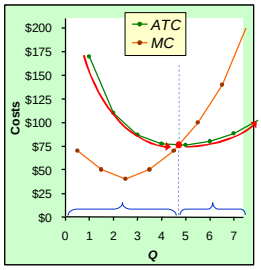
At any Q below or above 5, ATC > $76.

EXAMPLE 2: ATC and MC

When *MC* < *ATC*, *ATC* is falling.

When *MC* > *ATC*, *ATC* is rising.

The *MC* curve crosses the *ATC* curve at the *ATC* curve's minimum.



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The textbook gives a nice analogy to help students understand this. A student's GPA is like ATC. The grade she earns in her next course is like MC. If her next grade (MC) is less than her GPA (ATC), then her GPA will fall. If her next grade (MC) is greater than her GPA (ATC), then her GPA will rise.

I suggest letting students read the GPA example in the book and giving them the following example in class:

You run a pizza joint. You're producing 100 pizzas per night, and your cost per pizza (ATC) is $3. The cost of producing one more pizza (MC) is $2. If you produce this pizza, what happens to ATC? Most students will understand immediately that ATC falls (albeit by a small amount). Instead, suppose the cost of producing one more pizza (MC) is $4. Then, producing this additional pizza causes ATC to rise.

Costs in the Short Run & Long Run

- Short run:
  Some inputs are fixed (*e.g.*, factories, land).
  The costs of these inputs are *FC*.
- Long run:
  All inputs are variable
  (*e.g.*, firms can build more factories,
  or sell existing ones).
- In the long run, *ATC* at any **Q** is cost per unit using the most efficient mix of inputs for that **Q** (*e.g.*, the factory size with the lowest *ATC*).

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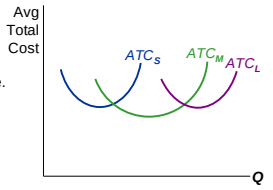
EXAMPLE 3: LRATC with 3 factory Sizes

Firm can choose from 3 factory sizes: **S**, **M**, **L**.

Each size has its own *SRATC* curve.

The firm can change to a different factory size in the long run, but not in the short run.

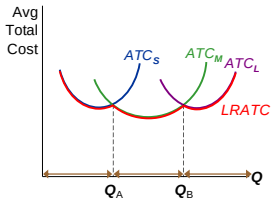


EXAMPLE 3: LRATC with 3 factory Sizes

To produce less than Q_A, firm will choose size **S** in the long run.

To produce between Q_A and Q_B, firm will choose size **M** in the long run.

To produce more than Q_B, firm will choose size **L** in the long run.



The following might be helpful:

After the first paragraph displays, pick a Q a little to the left of Q_A. From this Q, go up to the ATC curves. Notice that cost per unit is lower for the small factory than the medium one. The firm may be stuck with a medium factory in the short run, but in the long run – if it wishes to produce this level of output – it will choose the small factory to have the lowest cost per unit. Hence, for $Q < Q_A$, the LRATC curve is the portion of ATC_S from 0 to Q_A.

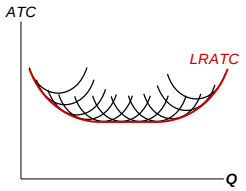
After the second paragraph displays, pick a Q a little to the right of Q_A. From this Q, go up to the ATC curves. Notice that cost per unit is lower for the medium factory than the small one. The firm may be stuck with a small factory in the short run, but in the long run – if it wishes to produce this level of output – it will choose the medium factory to have the lowest cost per unit. Hence, for $Q_A < Q < Q_B$, the LRATC curve is the portion of ATC_M from Q_B to Q_A.

The same type of argument illustrates the logic in the third paragraph.

A Typical LRATC Curve

In the real world, factories come in many sizes, each with its own *SRATC* curve.

So a typical *LRATC* curve looks like this:

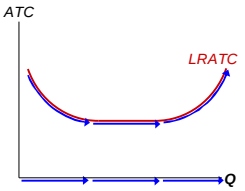


How ATC Changes as the Scale of Production Changes

Economies of scale: *ATC* falls as ***Q*** increases.

Constant returns to scale: *ATC* stays the same as ***Q*** increases.

Diseconomies of scale: *ATC* rises as ***Q*** increases.



How ATC Changes as the Scale of Production Changes

- Economies of scale occur when increasing production allows greater specialization: workers more efficient when focusing on a narrow task.
  - More common when ***Q*** is low.
- Diseconomies of scale are due to coordination problems in large organizations. *E.g.*, management becomes stretched, can't control costs.
  - More common when ***Q*** is high.

CONCLUSION

- Costs are critically important to many business decisions, including production, pricing, and hiring.
- This chapter has introduced the various cost concepts.
- The following chapters will show how firms use these concepts to maximize profits in various market structures.

CHAPTER SUMMARY

- Implicit costs do not involve a cash outlay, yet are just as important as explicit costs to firms' decisions.
- Accounting profit is revenue minus explicit costs. Economic profit is revenue minus total (explicit + implicit) costs.
- The production function shows the relationship between output and inputs.

CHAPTER SUMMARY

- The marginal product of labor is the increase in output from a one-unit increase in labor, holding other inputs constant. The marginal products of other inputs are defined similarly.
- Marginal product usually diminishes as the input increases. Thus, as output rises, the production function becomes flatter, and the total cost curve becomes steeper.
- Variable costs vary with output; fixed costs do not.

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CHAPTER SUMMARY

- Marginal cost is the increase in total cost from an extra unit of production. The MC curve is usually upward-sloping.
- Average variable cost is variable cost divided by output.
- Average fixed cost is fixed cost divided by output. AFC always falls as output increases.
- Average total cost (sometimes called "cost per unit") is total cost divided by the quantity of output. The ATC curve is usually U-shaped.

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CHAPTER SUMMARY

- The MC curve intersects the ATC curve at minimum average total cost.
  When MC < ATC, ATC falls as ***Q*** rises.
  When MC > ATC, ATC rises as ***Q*** rises.
- In the long run, all costs are variable.
- Economies of scale: ATC falls as ***Q*** rises.
  Diseconomies of scale: ATC rises as ***Q*** rises.
  Constant returns to scale: ATC remains constant as ***Q*** rises.

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The Complete Data for Example 2

Q	*FC*	*VC*	*TC*	*AFC*	*AVC*	*ATC*	*MC*
0	$100	$0	$100	n/a	n/a	n/a	
							$70
1	100	70	170	$100	$70	$170	
							50
2	100	120	220	50	60	110	
							40
3	100	160	260	33.33	53.33	86.67	
							50
4	100	210	310	25	52.50	77.50	
							70
5	100	280	380	20	56.00	76	
							100
6	100	380	480	16.67	63.33	80	
							140
7	100	520	620	14.29	74.29	88.57	
							200
8	100	720	820	12.50	90	102.50	

This slide is not intended to be part of the presentation, but you or your students might be interested in seeing the numbers behind the graphs.