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The Costs of Production

PRINCIPLES OF MICROECONOMICS FOURTH CANADIAN EDITION

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Canadian adaptation by Marc Prud'Homme

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ACTIVE LEARNING 1: Brainstorming

You run General Motors.

- List 3 different costs you have.
- List 3 different business decisions that are affected by your costs.



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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.

$$\text{Profit} = \text{Total revenue} - \text{Total cost}$$

the amount a
firm receives
from the sale
of its output

the market
value of the
inputs a firm
uses in
production

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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.



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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.

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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.

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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

- you rent your office space
- you own your office space

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ACTIVE LEARNING 2: Answers

The rent on office space increases \$500/month.

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

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The Production Function

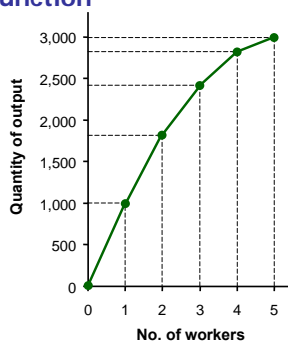
- A **production function** shows the relationship between the quantity of inputs used to produce a good, and the quantity of output of that good.
- It can be represented by a table, equation, or graph.
- Example 1:
 - Farmer Jack grows wheat.
 - He has 5 acres of land.
 - He can hire as many workers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

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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



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Marginal Product

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

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EXAMPLE 1: Total & Marginal Product

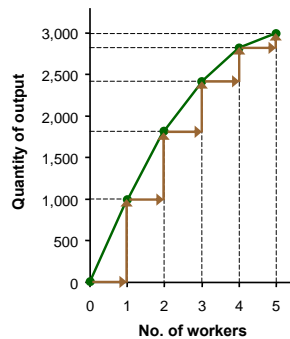
L (no. of workers) of wheat	Q (bushels of wheat)	MPL
$\Delta L = 1$	0	0
$\Delta L = 1$	1	1000
$\Delta L = 1$	2	1800
$\Delta L = 1$	3	2400
$\Delta L = 1$	4	2800
$\Delta L = 1$	5	3000

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EXAMPLE 1: MPL = Slope of Prod Function

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



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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.

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Why MPL Diminishes

- **Diminishing marginal product:**
the marginal product of an input declines as the quantity of the input increases (other things equal)
E.g., Farmer Jack's output rises by a smaller and smaller amount for each additional worker. Why?
- If Jack increases workers but not land, the average worker has less land to work with, so will be less productive.
- In general, *MPL* diminishes as *L* rises whether the fixed input is land or capital (equipment, machines, etc.).

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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....

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EXAMPLE 1: Farmer Jack's Costs

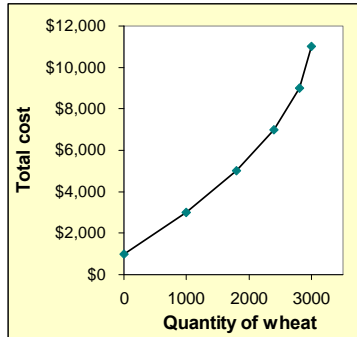
<i>L</i> (no. of workers) of wheat	<i>Q</i> (bushels of wheat)	cost of land	cost of labour	Total Cost
0	0	\$1,000	\$0	\$1,000
1	1000	\$1,000	\$2,000	\$3,000
2	1800	\$1,000	\$4,000	\$5,000
3	2400	\$1,000	\$6,000	\$7,000
4	2800	\$1,000	\$8,000	\$9,000
5	3000	\$1,000	\$10,000	\$11,000

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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



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Marginal Cost

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

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

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EXAMPLE 1: Total and Marginal Cost

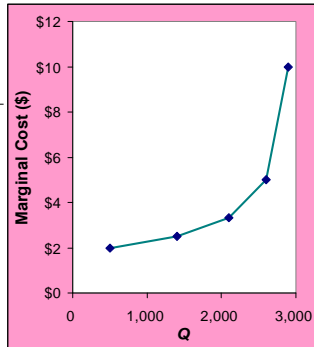
	Q (bushels of wheat)	Total Cost	Marginal Cost (MC)
	0	\$1,000	
$\Delta Q = 1000$	1000	\$3,000	$\Delta TC = \$2000$ \$2.00
$\Delta Q = 800$	1800	\$5,000	$\Delta TC = \$2000$ \$2.50
$\Delta Q = 600$	2400	\$7,000	$\Delta TC = \$2000$ \$3.33
$\Delta Q = 400$	2800	\$9,000	$\Delta TC = \$2000$ \$5.00
$\Delta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

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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	



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Why MC Is Important

- Farmer Jack is rational and wants to maximize his profit. To increase profit, should he produce more wheat, or less?
- 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.)



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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)** = $FC + VC$

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EXAMPLE 2

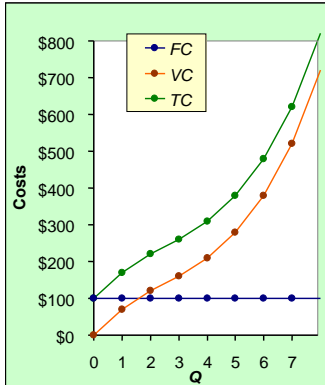
- Our second example is more general, applies to any type of firm, producing any good with any types of inputs.

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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

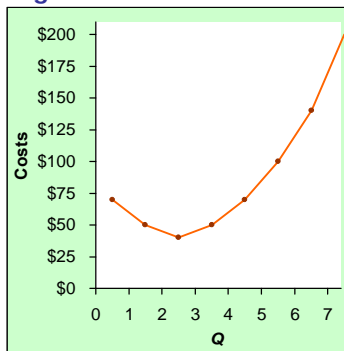


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EXAMPLE 2: Marginal Cost

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

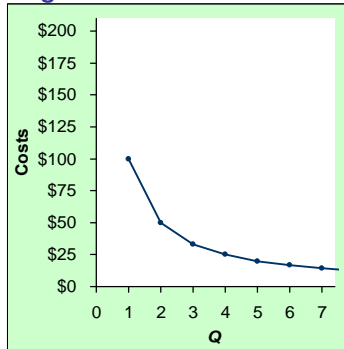


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EXAMPLE 2: Average Fixed Cost

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

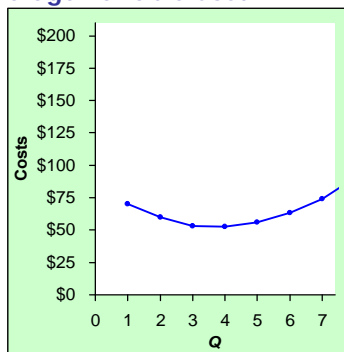


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EXAMPLE 2: Average Variable Cost

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,

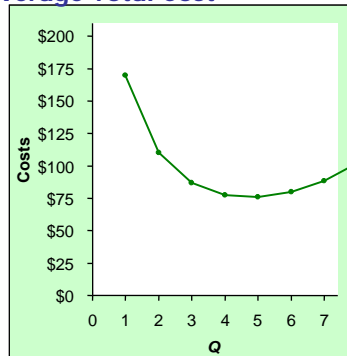
$$ATC = AFC + AVC$$

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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

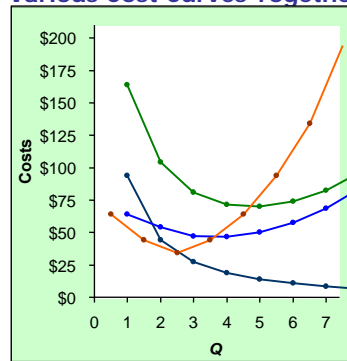


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EXAMPLE 2: The Various Cost Curves Together

—●—	ATC
—●—	AVC
—●—	AFC
—●—	MC



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ACTIVE LEARNING 3: Costs

Fill in the blank spaces of this table.

Q	VC	TC	AFC	AVC	ATC	MC
0		\$50	n.a.	n.a.	n.a.	
1	10			\$10	\$60.00	\$10
2	30	80				
3			16.67	20	36.67	30
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	

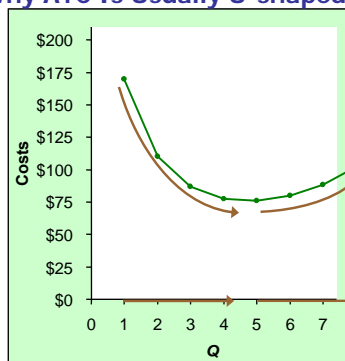
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EXAMPLE 2: Why ATC Is Usually U-shaped

As Q rises:

Initially,
falling AFC
pulls ATC down.

Eventually,
rising AVC
pulls ATC up.



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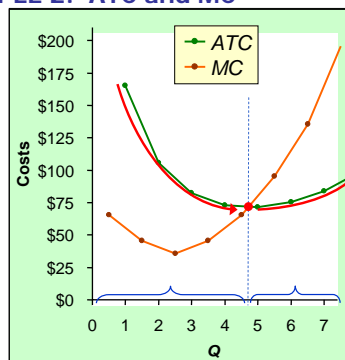
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EXAMPLE 2: ATC and MC

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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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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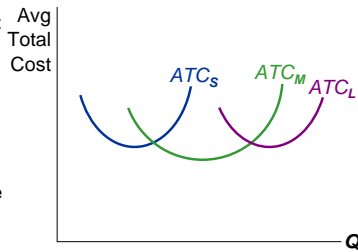
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EXAMPLE 3: LRATC with 3 Factory Sizes

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.



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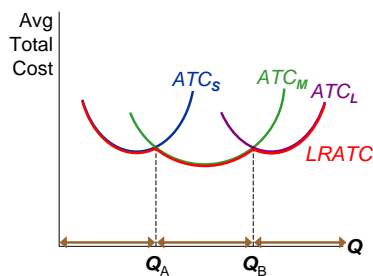
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EXAMPLE 3: LRATC with 3 Factory Sizes

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.



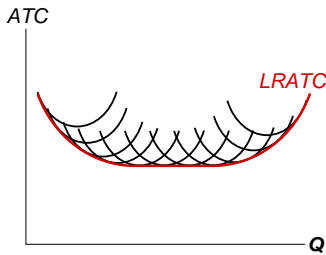
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A Typical LRATC Curve

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

So a typical LRATC curve looks like this:



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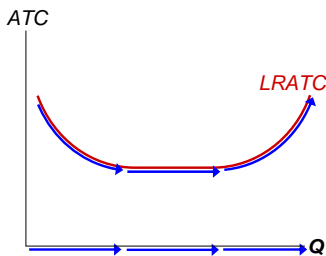
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How ATC Changes as the Scale of Production Changes

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.



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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.

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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 labour is the increase in output from a one-unit increase in labour, 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.

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	

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End: Chapter 13

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