Cost	Description	Calculation
Total cost (TC)	All costs	TC = FC + VC
Fixed cost (FC)	Costs that do not vary with quantity of output	
Variable cost (VC)	Costs that vary with the quantity of output	
Average fixed cost		AFC = FC/Q
Average variable cost		AVC = VC/Q
Average total cost		ATC = TC/Q
Marginal cost	Change in total cost due to the production of an additional unit of output	MC = ΔTC/ΔQ

THE SHAPE OF SR COST CURVE: TC, VC, FC, ATC, AVC, AFC, MC

练一练

Q	AFC	AVC	ATC	MC	TVC	TFC	TC
1	80	5	85	85	5	80	85
2	40	$\frac{15}{2}$	$\frac{95}{2}$	10	15	80	95
3	$\frac{80}{3}$	10	$\frac{110}{3}$	15	30	60	110
4	20	$\frac{50}{4}$	$\frac{130}{4}$	20	50	80	130
5	16	16	32	30	80	80	160

ISOCOST

- ➢ **Function:** $TC = wl + rk$

    - ✧ **Intercept(交点):**

        - ✓ **Horizontal:** $\frac{TC}{w}$

        - ✓ **Vertical:** $\frac{TC}{r}$

    - ✧ **Slope（斜率）:** $-\frac{w}{r}$

        - ✓ Negative, because ↑L you must ↓ K or ↑ K you must ↓ L

        - ✓ Tradeoff

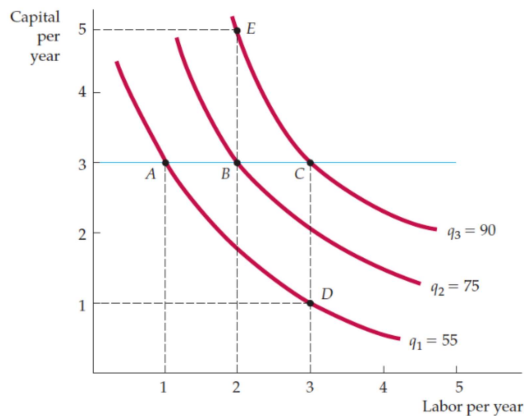| TC	Total cost
r	price per unit of capital services
K	Quantity of Capital
w	wage rate
L	Quantity of Labor

ISOQUANT

a. **Definition:** isoquant Curve showing all possible combinations of inputs that yield the same output. (同一条线上，不同数量组合的 L 和 K 生产出 q 相同)

- ✓ 特点

    - ✓ Isoquant further away from the origin allow you to produce higher levels of output because you are utilizing more L, K （离原点越远，产量越高）

    - ✓ Just like L: as you utilize more K, it also exhibits diminishing marginal product of K

    - ✓ Why the isoquant is drawn as downward sloping, convex functions?

Capital per year axis with values 5, 4, 3, 2, 1. Points E, A, B, C, D. Isoquants $q_3 = 90$, $q_2 = 75$, $q_1 = 55$. Labor per year axis 1, 2, 3, 4, 5.

- ✓ **Slope:** (isoquant 的斜率是 MRTS)

  - ✓ Slope of isoquant is the **MRTS**: marginal rate of technical substitution:

练一练

Suppose that the production function for Alfredo Barbuda, a producer of fine violins, is given by the following: $Q = 10K^{0.5}L^{0.5}$.

a) Suppose that Alfredo is currently using 1 unit of capital. If he hires 4 workers, how many violins will they produce? 20

b) Suppose that Alfredo is currently using not 1, but 2 units of capital. How many workers must he hire to match the level of production you found in (a)? 2.

c) Rework your answer to (b), assuming that Alfredo is currently using 4 units of capital. 1

d) Calculate the number in the following table

MPK	$MPK = 5\left(\frac{L}{K}\right)^{\frac{1}{2}}$
MPL	$= 5\left(\frac{K}{L}\right)^{\frac{1}{2}}$
MRST (MPL/MPK)	$\frac{K}{L}$
How to express K by w,r,L	$K = \frac{w}{r} \cdot L$
Calculate the demand function of labour	
Calculate the demand function of capital	
Total cost function	$TC = wL + rk.$
Average cost function	

$$TC = \frac{Q}{5}\sqrt{rw}$$

$$\frac{1}{10}\sqrt{rw} \qquad \frac{1}{5}$$

4Q.

Marginal cost function	

COST MINIMIZATION

➢ Putting the production function and cost line together, we observe how firms cost-minimize by observing L* and K*

  ✧ 2 methods to answer:

    ✓ we only concern the isoquant that represents q unit of output

    ✓ Find lowest cost of production by chasing the isocost line to the origin that still allows us to produce q unit of output

➢ **1st example** of cost minimization: specific output good

  ✧ look for tangency between isocost and isoquant line

    ✓ **isocost line:** slope $= -\frac{w}{r}$

    ✓ **isoquant**: slope $= MRTS = -\frac{MPL}{MPK}$

    ✓ **tangency condition:** $\frac{w}{r} = \frac{MPL}{MPK}$

  ✧ **2nd example of** with some rearranging:

    ✓ $\frac{MPL}{w} = \frac{MPK}{r}$ $\Rightarrow$ similar to equal margin principle
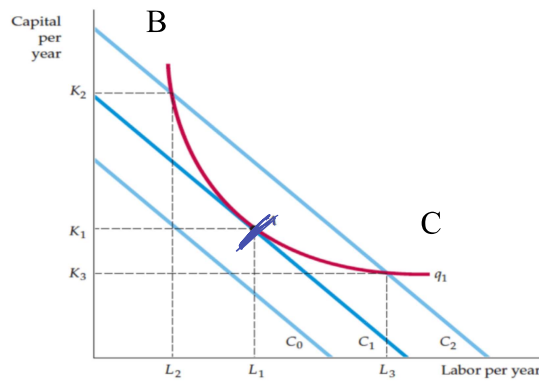
      • $\frac{MPL}{w}$: output generated when \$1 is spent on hiring labor

        (每花在 L 上的钱可以额外多生产出多少 q)

      • $\frac{MPK}{r}$: output generated when \$1 is spent on renting capital

        (每花在 K 上的钱可以额外多生产出多少 q

  ✧ **Graph:**

- ✧ at point B: $\frac{MPL}{w} > \frac{MPK}{r}$

  - ✓ using too much capital, so hiring more labor until at point A ($\frac{MPL}{w} = \frac{MPK}{r}$)

    (因为现在多招 L 可以给公司带来的额外产量多，直到他们的边际效应一样 A 点)

- ✧ at point C: $\frac{MPL}{w} < \frac{MPK}{r}$

  - ✓ using too much labor, so renting more capital until at point A ($\frac{MPL}{w} = \frac{MPK}{r}$)

    (因为现在多 rent k 可以给公司带来的额外产量多, 直到他们的边际效应一样 A 点)

- ✧ **at point A: cost minimization**

练一练

Q1. Do the following functions exhibit increasing, constant or decreasing returns to scale? What happens to the marginal product of each individual factor as that factor is increased and the other factor held constant.

a. q = 3L + 2K   *cons*
b. q = (2L + 2K)$^{0.5}$ *decr*
c. q = 3LK^2 *incr*
d. q = L$^{0.5}$K$^{0.5}$ *const*
e. q = 4L$^{0.5}$ + 4K   *decr*

➢ **Summary:**

LONG RUN PRODUCTION AND COST

PRODUCTION FUNCTION

The long run is a time frame in which the quantities of all resources, including capital, can be varied. Long-run decisions are not easily reversed.

The firm's production function is the relationship between the maximum output attainable and the quantities of both capital and labour.

Marginal Product decreasing :

A firm's production function exhibits diminishing marginal product to labour (for a given plant) as well as diminishing marginal product to capital (for a quantity of labour).

		Output (pizza per day)			
Labour		1 Oven	2 Oven	3 Oven	4 Oven
1		4	10	13	15
2		10	15	18	21
3		13	18	22	24
4		15	20	24	26
5		16	21	25	27

THE SHAPE OF THE LR COST CURVES

Average cost per Pizza

Pizza	Average cost per Pizza				
4		1 Oven	2 Oven	3 Oven	4 Oven
10		12. 50	15. 00	20. 67	26. 67
13		7. 50	7. 50	9. 42	11. 57
15		7. 69	6. 92	7. 69	9. 36
16		8. 33	6. 67	7. 33	8. 33
20		9. 38	6. 77	7. 19	8. 07
25			7. 50	6. 88	7. 29
				8. 00	7. 50

Long-run average cost curve 画图
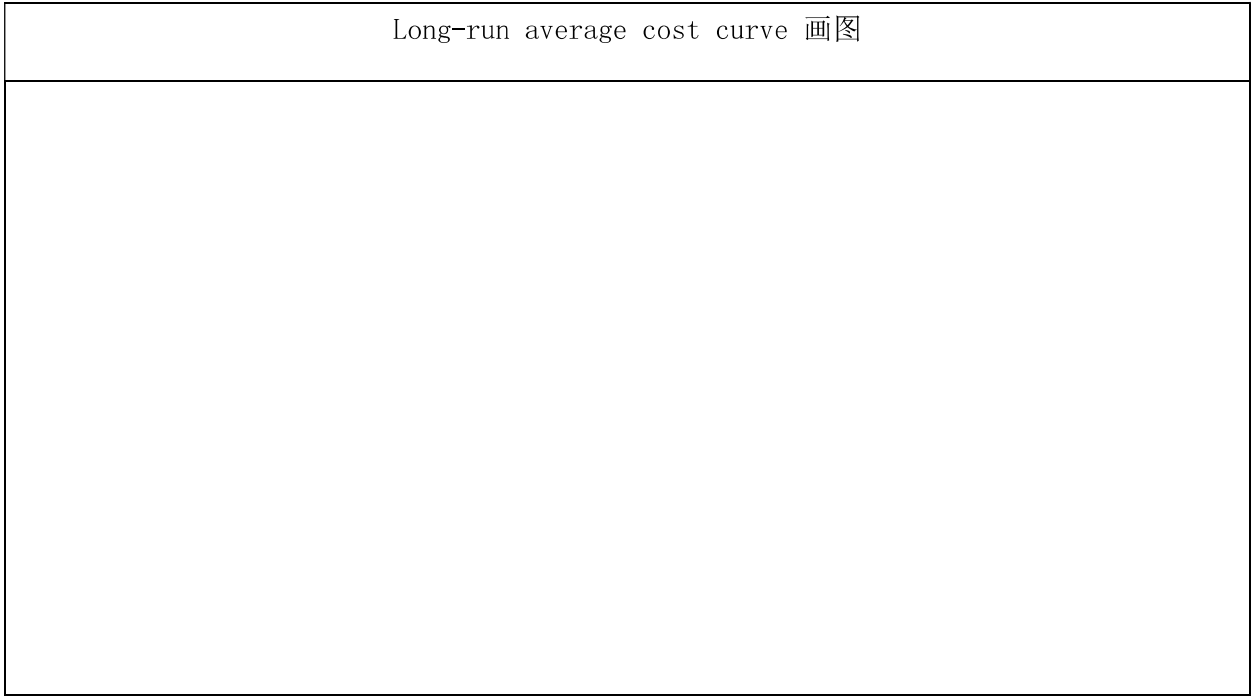
➢ **In the LR:** the curves are u-shaped because of different returns to scale

- ✓ Economies of scale are features of a firm's technology that lead to falling long-run average cost as output increases.
- ✓ Diseconomies of scale are features of a firm's technology that lead to rising long-run average cost as output increases.
- ✓ Constant returns to scale are features of a firm's technology that lead to constant long-run average cost as output increases.

Long Run Average Cost (LRAC)
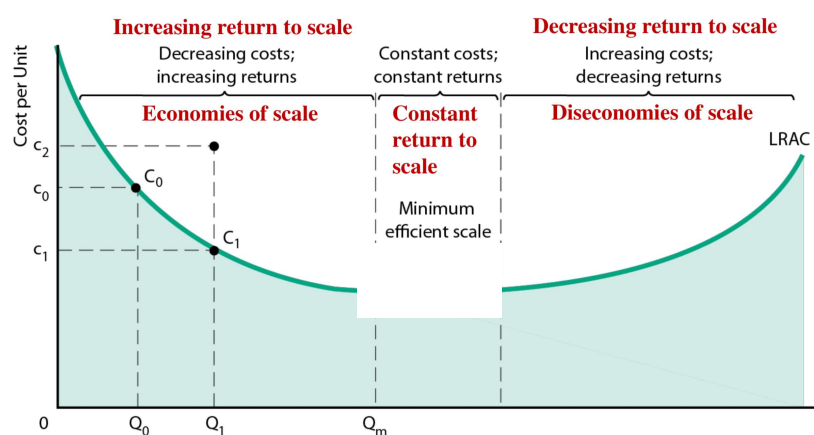
LRMC will pass through the min LRAC curve

- ✧ cause the AC to change from negatively sloped curve to a positively sloped function

inflection point occurs when $MC = AC$ (at the min of LRAC)

RELATIONSHIP BETWEEN COST AND PRODUCTION

Over the output range with increasing marginal product, marginal cost falls as output increases. （当在 MP 上升的阶段，MC 是下降的。）

Over the output range with diminishing marginal product, marginal cost rises as output increases. （当在 MP 下降的阶段，MC 是上升的）

for the LRAC to fall, LRMC must be lower than the AC → pulling the average down

for the LRAC to rise, LRMC must be higher than the AC → pulling the average up
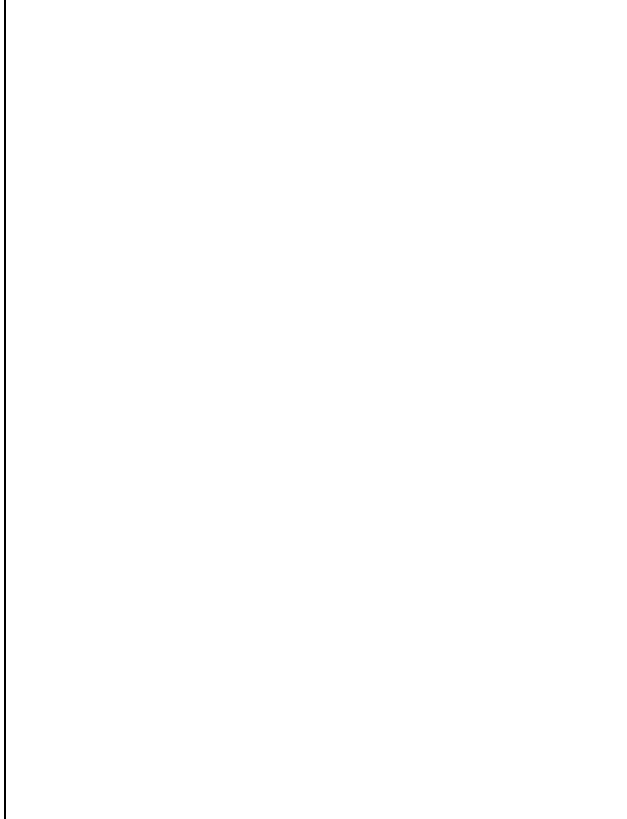
总结

ECONOMIES AND DISECONOMIES OF SCOPE

区分：

A company that benefits from economies of scope has lower average costs because costs are spread over a variety of products.

A company that benefits from economies of scale has a lower average cost because costs decrease as the amount produced increases.