# Intermediate Microeconomics

Chapter 8
*Technology and Production*

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## Technology

- *Technology* = firm's options for combining inputs to obtain output
- Focus on only two inputs: labor ($L$) and capital ($K$)
- *Production function* = schedule that shows the *highest* level of output the firm can produce from a given combination of inputs
- *Total product of L and K* = the highest total amount of output the firm can produce given the amount of inputs
- Example: $F(K, L) = 3L^2 + 5K$

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## Production function

- Production function is similar to utility function, with one major difference: if utility is purely ordinal (its value doesn't matter in itself), the value of the production function *does* matter
- *Isoquant* = curve showing all input combinations that yield the same level of output (similar concept to indifference curve)
- *Isoquant map* = collection of all isoquants corresponding to a particular production function

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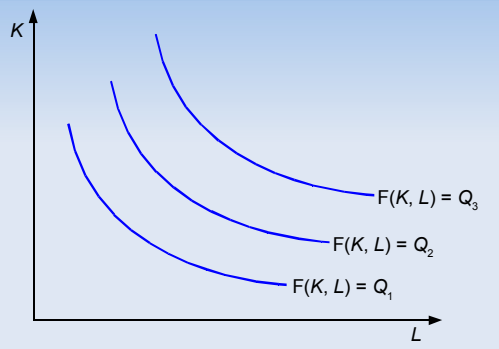
## Isoquant map

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## Decision-making horizon

- Feasible choices of input combinations could depend on input types:
  - fixed factor = its level cannot be changed over the relevant planning horizon
  - variable factor = its level can be changed
- Hence, planning horizon for production decisions is important:
  - short run = time period over which only one of the firm's inputs is variable and all other are fixed
  - long run = time period long enough so that all inputs are variable

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## Properties of production function

- Marginal physical product
- Marginal rate of technological substitution
- Returns to scale

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## Marginal physical product

- *Marginal physical product* = extra amount of output that can be produced when the firm uses an additional unit of a specific input, holding the levels of all other inputs constant
- Algebraically: derivative of production function with respect to that particular input
- For example, marginal physical product of labor:

$$MPP_L = \frac{\Delta Q}{\Delta L}$$

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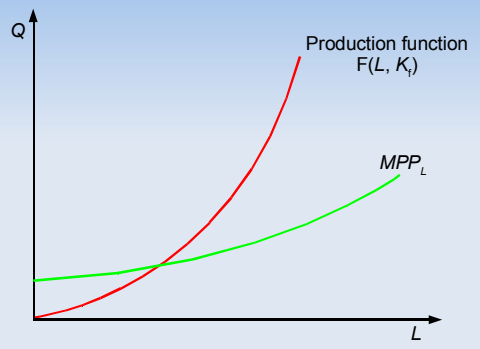
## Increasing marginal returns

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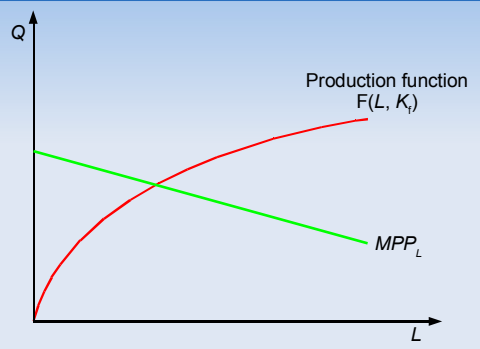
## Decreasing marginal returns

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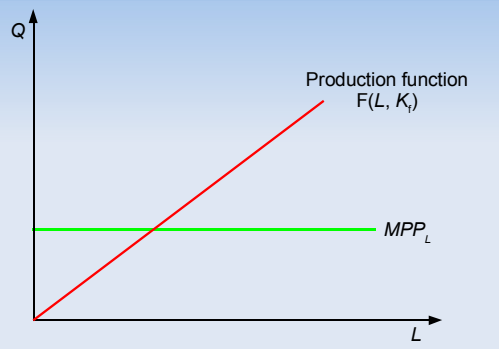
## Constant marginal returns

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## Marginal rate of technical substitution

- *Marginal rate of technical substitution* (*MRTS*) = rate at which the available technology allows the substitution of one factor for another
- Algebraically: the negative of the slope of the isoquant ⇒ equivalent to the marginal rate of substitution from utility theory
- In our labor/capital example:

$$MRTS = -\frac{\Delta K}{\Delta L}$$

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## Marginal rate of technical substitution

- Marginal rate of technical substitution (MTRS):
  - *increasing* = technology such that the marginal physical product of an input rises as the amount of that input used increases
  - *constant* = technology such that the marginal physical product of an input remains unchanged as the amount of that input increases
  - *decreasing* = technology such that the marginal physical product of an input falls as the amount of that input used increases

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## Two polar cases

- *Perfect substitutes* = two inputs that have a constant marginal rate of technical substitution of one for the other
- *No factor substitution* = inputs that cannot be substituted for one another in any proportion, but need to be used together in a constant proportion

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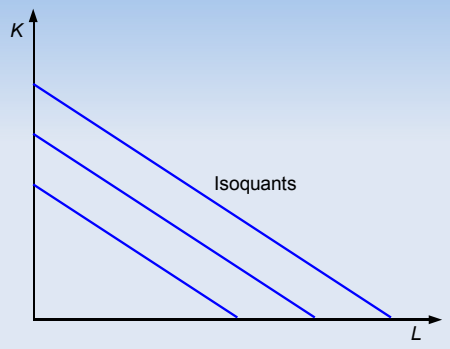
## Perfect substitutes

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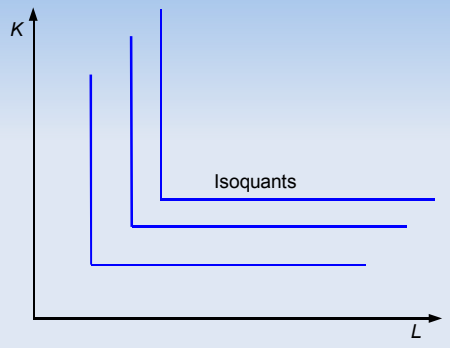
## No factor substitution

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## The relationship between MRTS and MPP

- Along an isoquant, as the amount of inputs change by $\Delta L$ and $\Delta K$, output remains unchanged:

$$MPP_L \times \Delta L + MPP_K \times \Delta K = 0$$

- Hence, $MPP_L \times \Delta L = -MPP_K \times \Delta K$
- This in turn means that:

$$MRTS = \frac{MPP_L}{MPP_K}$$

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## Returns to scale

- *Increasing returns to scale* = technology such that a proportional increase in *all* input levels leads to greater than proportionate output growth
- *Decreasing returns to scale* = technology such that a proportional increase in all input levels leads to less than proportionate output growth
- *Constant returns to scale* = technology such that a proportional increase in all input levels leads to a proportionate output growth

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