Consumer Behavior

- Consumer Opportunities
  - The possible goods and services consumer can afford to consume.

- Consumer Preferences
  - The goods and services consumers actually consume.
  - Given the choice between 2 bundles of goods a consumer either
    - Prefers bundle A to bundle B: A ≻ B, or U(A)>U(B)
    - Prefers bundle B to bundle A: A ≺ B, or U(A)<U(B)
    - Is indifferent between the two: A ∼ B, or U(A)=U(B)

Indifference Curve Analysis

- Indifference Curve
  - A curve that defines the combinations of 2 or more goods that give a consumer the same level of satisfaction.
  - Represented by U(X,Y), whose partial derivatives are denoted U_X, U_Y

- Marginal Rate of Substitution
  - The rate at which a consumer is willing to substitute one good for another and maintain the same satisfaction level.
  - \( MRS = \frac{U_X}{U_Y} \)

Consumer Preference Ordering Properties

- Complete—everything can be compared
- Monotone—More is Better
- Diminishing Marginal Rate of Substitution
- Transitive

Complete Preferences

- Completeness Property
  - Consumer is capable of expressing preferences (or indifference) between all possible bundles. ("I don’t know" is NOT an option!)
    - If the only bundles available to a consumer are A, B, and C, then the consumer
      - is indifferent between A and C (they are on the same indifference curve).
      - will prefer B to A.
      - will prefer B to C.
**More Is Better!**

- **More Is Better Property**
  - Bundles that have at least as much of every good and more of some good are preferred to other bundles.
  - Bundle B is preferred to A since B contains at least as much of good Y and strictly more of good X.
  - Bundle B is also preferred to C since B contains at least as much of good X and strictly more of good Y.
  - More generally, all bundles on IC₂ are preferred to bundles on IC₁ or IC₃. And all bundles on IC₄ are preferred to IC₃.

**Changes in Price**

- **Changes in the Budget Line**
  - An increase in the price of good X rotates the budget line counterclockwise ($P_{X} > P_{X'}$).
  - An increase rotates the budget line clockwise (not shown).

**Changes in Income**

- **Diminishing Marginal Rate of Substitution**
  - The marginal rate of substitution is diminishing.
  - The slope of the indifference curve equals the budget line.
  - The optimum occurs at a point where $MRS = \frac{P_{X}}{P_{Y}}$.

**Consistent Bundle Orderings**

- **Transitivity Property**
  - For the three bundles A, B, and C, the transitivity property implies that if C > B and B > A, then C > A.
  - Transitive preferences along with the more-is-better property imply that indifference curves will not intersect.
  - The consumer will not get caught in a perpetual cycle of indecision.

**The Budget Constraint**

- **Opportunity Set**
  - The set of consumption bundles that are affordable.
  - $P_{X} \cdot X + P_{Y} \cdot Y = M$.

- **Budget Line**
  - The bundles of goods that exhaust a consumer's income.
  - $P_{X} \cdot X + P_{Y} \cdot Y = M$.

- **Market Rate of Substitution**
  - The slope of the budget line $\frac{-P_{X}}{P_{Y}}$.

**Changes in the Budget Line**

- **Consumer Optimum**
  - The optimal bundle is an affordable bundle that yields the highest level of satisfaction.
  - Consumer equilibrium occurs at a point where $MRS = \frac{P_{X}}{P_{Y}}$.
  - Equivalently, the slope of the indifference curve equals the budget line.
  - Or else the optimum is at a corner.
Price Changes and Consumer Equilibrium

• Substitute Goods
  - An increase (decrease) in the price of good X leads to an increase (decrease) in the consumption of good Y.
  - Examples:
    – Coke and Pepsi.
    – Verizon Wireless or T-Mobile.

• Complementary Goods
  - An increase (decrease) in the price of good X leads to a decrease (increase) in the consumption of good Y.
  - Examples:
    – DVDs and DVD players.
    – Computer CPUs and monitors.

Income Changes and Consumer Equilibrium

• Normal Goods
  - Good X is a normal good if an increase (decrease) in income leads to an increase (decrease) in its consumption.

• Inferior Goods
  - Good X is an inferior good if an increase (decrease) in income leads to a decrease (increase) in its consumption.

Decomposing the Income and Substitution Effects

Initially, bundle A is consumed.
A decrease in the price of good X expands the consumer’s opportunity set.
The substitution effect (SE) causes the consumer to move from bundle A to B.
A higher “real income” allows the consumer to achieve a higher indifference curve.
The movement from bundle B to C represents the income effect (IE). The new equilibrium is achieved at point C.

Normal Goods

An increase in income increases the consumption of normal goods. 
\( (M_X < M_Y) \).

Individual Demand Curve

• An individual’s demand curve is derived from each new equilibrium point found on the indifference curve as the price of good X is varied.
Market Demand

- The market demand curve is the horizontal summation of individual demand curves.
- It indicates the total quantity all consumers would purchase at each price point.

Individual Demand Curves
Market Demand Curve

A buy-one, get-one free pizza deal.

Conclusion

- Indifference curve properties reveal information about consumers’ preferences between bundles of goods.
  - Completeness.
  - More is better.
  - Diminishing marginal rate of substitution.
  - Transitivity.
- Indifference curves along with price changes determine individuals’ demand curves.
- Market demand is the horizontal summation of individuals’ demands.

Production and Cost: Overview

I. Production Analysis
   - Total Product, Marginal Product, Average Product
   - Isoquants
   - Isocosts
   - Cost Minimization

II. Cost Analysis
   - Total Cost, Variable Cost, Fixed Costs
   - Cubic Cost Function
   - Cost Relations

III. Multi-Product Cost Functions

IV. Learning Curve

Total Product

- Cobb-Douglas Production Function
- Example: \( Q = F(K,L) = K^{0.5}L^{0.5} \)
  - \( K \) is fixed at 16 units.
  - Short run production function:
    \( Q = (16)^{0.5}L^{0.5} = 4L^{0.5} \)
  - Production when 100 units of labor are used?
    \( Q = 4(100)^{0.5} = 4(10) = 40 \) units

Production Analysis

- Production Function
  - \( Q = F(K,L) \)
    - The maximum amount of output that can be produced with \( K \) units of capital and \( L \) units of labor.
- Short-Run vs. Long-Run Decisions
- Fixed vs. Variable Inputs
Marginal Productivity Measures

- Marginal Product of Labor: \( MP_L = \frac{dQ}{dL} \)
  - Measures the output produced by the last worker.
  - Slope of the short-run production function (with respect to labor).
- Marginal Product of Capital: \( MP_K = \frac{dQ}{dK} \)
  - Measures the output produced by the last unit of capital.
  - When capital is allowed to vary in the short run, \( MP_K \) is the slope of the production function (with respect to capital).

Average Productivity Measures

- Average Product of Labor
  - \( AP_L = \frac{Q}{L} \)
  - Measures the output of an “average” worker.
  - Example: \( Q = F(K, L) = K^{0.5} L^{0.5} \) if the inputs are \( K = 16 \) and \( L = 16 \), then the average product of labor is \( AP_L = \frac{[(16)^{0.5} (16)^{0.5}]}{16} = 1 \).
- Average Product of Capital
  - \( AP_K = \frac{Q}{K} \)
  - Measures the output of an “average” unit of capital.
  - Example: \( Q = F(K, L) = K^{0.5} L^{0.5} \) if the inputs are \( K = 16 \) and \( L = 16 \), then the average product of labor is \( AP_K = \frac{[(16)^{0.5} (16)^{0.5}]}{16} = 1 \).

Increasing, Diminishing and Negative Marginal Returns

<table>
<thead>
<tr>
<th>MP</th>
<th>AP</th>
<th>Q = F(K, L)</th>
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<tbody>
<tr>
<td>Increasing Marginal Returns</td>
<td>Increasing Marginal Returns</td>
<td>Negative Marginal Returns</td>
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Guiding the Production Process

- Producing on the production function
  - Aligning incentives to induce maximum sustainable worker effort.
- Employing the right level of inputs
  - When labor or capital vary in the short run, to maximize profit a manager will hire
    - labor until the value of marginal product of labor equals the wage: \( VMP_L = w \), where \( VMP_L = P \times MP_L \).
    - capital until the value of marginal product of capital equals the rental rate: \( VMP_K = r \), where \( VMP_K = P \times MP_K \).

Isoquant

- The combinations of inputs (K, L) that yield the producer the same level of output.
- The shape of an isoquant reflects the ease with which a producer can substitute among inputs while maintaining the same level of output.

Marginal Rate of Technical Substitution (MRTS)

- The rate at which two inputs are substituted while maintaining the same output level.
  \[
  MRTS_{KL} = \frac{MP_L}{MP_K}
  \]
Linear Isoquants
- Capital and labor are perfect substitutes
  - $Q = aK + bL$
  - $\text{MRTS}_{KL} = b/a$
  - Linear isoquants imply that inputs are substituted at a constant rate, independent of the input levels employed.

Leontief Isoquants
- Capital and labor are perfect complements.
- Capital and labor are used in fixed-proportions.
- $Q = \min\{bK, cL\}$
- Since capital and labor are consumed in fixed proportions there is no input substitution along isoquants (hence, no $\text{MRTS}_{KL}$).

Cobb-Douglas Isoquants
- Inputs are not perfectly substitutable.
- Diminishing marginal rate of technical substitution.
  - As less of one input is used in the production process, increasingly more of the other input must be employed to produce the same output level.
  - $Q = K^aL^b$
  - $\text{MRTS}_{KL} = \frac{MP_L}{MP_K}$

Isocost
- The combinations of inputs that produce a given level of output at the same cost:
  - $wL + rK = C$
- Rearranging,
  - $K = \frac{(1/r)C - (w/r)L}{C}$
- For given input prices, isocosts farther from the origin are associated with higher costs.
- Changes in input prices change the slope of the isocost line.

Cost Minimization
- Marginal product per dollar spent should be equal for all inputs:
  - $\frac{MP_L}{w} = \frac{MP_K}{r}$
- But, this is just
  - $\text{MRTS}_{KL} = \frac{w}{r}$
Optimal Input Substitution

- A firm initially produces $Q_0$ by employing the combination of inputs represented by point A at a cost of $C_0$.
- Suppose $w_0$ falls to $w_1$.
  - The isocost curve rotates counterclockwise, which represents the same cost level prior to the wage change.
  - To produce the same level of output, $Q_0$, the firm will produce on a lower isocost line ($C_1$) at a point B.
- The slope of the new isocost line represents the lower wage relative to the rental rate of capital.

Cost Analysis

- Types of Costs
  - Fixed costs (FC)
  - Variable costs (VC)
  - Total costs (TC)
  - Sunk costs

Total and Variable Costs

$C(Q)$: Minimum total cost of producing alternative levels of output:

$$C(Q) = VC(Q) + FC$$

VC(Q): Costs that vary with output.

FC: Costs that do not vary with output.

Fixed and Sunk Costs

FC: Costs that do not change as output changes.

Sunk Cost: A cost that is forever lost after it has been paid.

Some Definitions

Average Total Cost

$$ATC = AVC + AFC$$

$$ATC = C(Q)/Q$$

Average Variable Cost

$$AVC = VC(Q)/Q$$

Average Fixed Cost

$$AFC = FC/Q$$

Marginal Cost

$$MC = ΔC/ΔQ$$

Fixed Cost

$$Q_o(ATC-AVC) = Q_o×AFC$$

$$= Q_o×(FC/Q_o) = FC$$
**Variable Cost**

\[ Q_0 \times AVC = Q_0 \frac{VC(Q_0)}{Q_0} = VC(Q_0) \]

**Total Cost**

\[ Q_0 \times ATC = Q_0 \frac{C(Q_0)}{Q_0} = C(Q_0) \]

---

**Cubic Cost Function**

- \( C(Q) = f + aQ + bQ^2 + cQ^3 \)
- Marginal Cost?
  - Memorize: \( MC(Q) = a + 2bQ + 3cQ^2 \)
  - Calculus: \( \frac{dC}{dQ} = a + 2bQ + 3cQ^2 \)

**An Example**

- Total Cost: \( C(Q) = 10 + Q + Q^2 \)
- Variable cost function: \( VC(Q) = Q + Q^2 \)
- Variable cost of producing 2 units: \( VC(2) = 2 + (2)^2 = 6 \)
- Fixed costs: \( FC = 10 \)
- Marginal cost function: \( MC(Q) = 1 + 2Q \)
- Marginal cost of producing 2 units: \( MC(2) = 1 + 2(2) = 5 \)

---

**Economies of Scale**

**Multi-Product Cost Function**

- \( C(Q_1, Q_2): \) Cost of jointly producing two outputs.
- General function form:
  \[ C(Q_1, Q_2) = f + aQ_1Q_2 + bQ_1^2 + cQ_2^2 \]
Economies of Scope

- \( C(Q_1, 0) + C(0, Q_2) > C(Q_1, Q_2) \).
  - It is cheaper to produce the two outputs jointly instead of separately.
- Example:
  - It is cheaper for Time-Warner to produce Internet connections and Instant Messaging services jointly than separately.

Cost Complementarity

- The marginal cost of producing good 1 declines as more of good two is produced:
  \[ \Delta MC_1(Q_1, Q_2)/\Delta Q_2 < 0. \]
- Example:
  - Cow hides and steaks.

Quadratic Multi-Product Cost Function

- \( C(Q_1, Q_2) = f + aQ_1Q_2 + (Q_1)^2 + (Q_2)^2 \)
- \( MC_1(Q_1, Q_2) = aQ_2 + 2Q_1 \)
- \( MC_2(Q_1, Q_2) = aQ_1 + 2Q_2 \)
- Cost complementarity: \( a < 0 \)
- Economies of scope: \( f > aQ_1Q_2 \)

Learning Curve

- Cost declines with accumulated output A
  - \( A = \sum Q_s, s=0 \text{ to } t \)
- Idea: efficiency improves with experience due to individual learning and better team coordination.
- Original examples: aircraft and ship building in WWII.
- Recent examples: microprocessors, fuel cells
- In \( MC = a - b \ln A \) is usual functional form
- The incremental cost decreases b% when accumulated output increases 1%

A Numerical Example:

- \( C(Q_1, Q_2) = 90 - 2Q_1Q_2 + (Q_1)^2 + (Q_2)^2 \)
- Cost Complementarity?
  - Yes, since \( a = -2 < 0 \)
  - \( MC_1(Q_1, Q_2) = -2Q_2 + 2Q_1 \)
- Economies of Scope?
  - Yes, since \( 90 > -2Q_1Q_2 \)

Conclusion

- To maximize profits (minimize costs) managers must use inputs such that the value of marginal of each input reflects price the firm must pay to employ the input.
- The optimal mix of inputs is achieved when the \( MRTS_{KL} = (w/r) \).
- Cost functions are the foundation for helping to determine profit-maximizing behavior in future chapters.