Microeconomics

Consumers

$\boldsymbol{x} = (x_1, x_2, ..., x_n)$

- Goods – what we purchase
- Preferences - some goods preferred to others
- Utility function u(x) - represents preferences
- Indifference curves - level sets of utility function

Can we change consumption and keep utility constant?

$$du(x_1, x_2) = \frac{\partial u}{\partial x_1} dx_1 + \frac{\partial u}{\partial x_2} dx_2 = 0$$

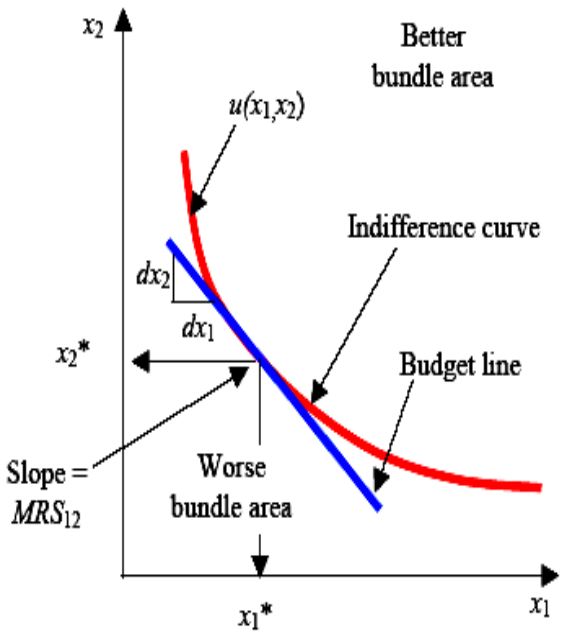
$$\frac{\frac{\partial u}{\partial x_1}}{\frac{\partial u}{\partial x_2}} = -\frac{dx_2}{dx_1}$$

Marginal Utility

$$MU_i = \frac{\partial u}{\partial x_i}$$

$$MRS_{12} = \frac{MU_1}{MU_2} = -\frac{dx_2}{dx_1}$$

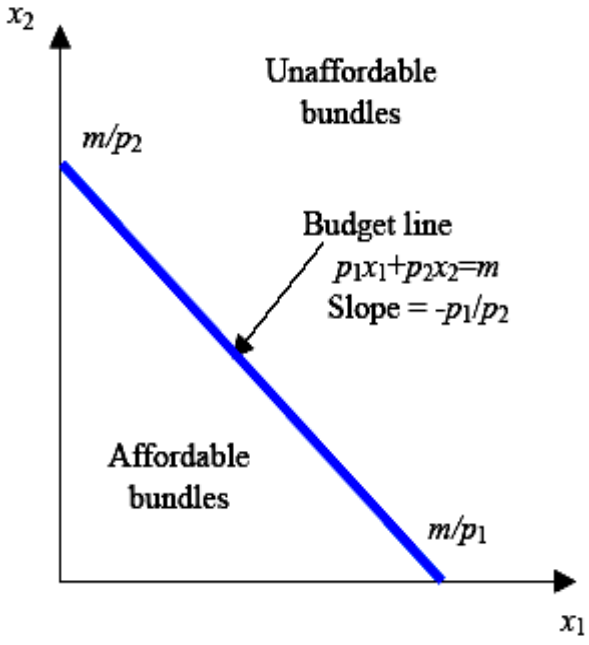
Marginal Rate of Substitution: rate at which a consumer can substitute good 1 for good 2



Consumer's Budget

- Consumers choose best bundles of goods they can afford on budget of $\$m$

$$p_1 x_1 + p_2 x_2 \leq m$$



Consumer's Problem

- **Consumer's Problem**

Maximize $u(\boldsymbol{x})$

subject to

$$\boldsymbol{p}\cdot\boldsymbol{x}\le m$$

$$\boldsymbol{x}\ge 0$$

- **Lagrangian** $L(x,\lambda)=u(x)+\lambda\left(m-\sum_{k=1}^{K}p_k x_k\right)$

- **Optimality conditions** $\dfrac{\partial L}{\partial x_k}=\dfrac{\partial u}{\partial x_k}-\lambda p_k=0,\quad k=1,\ldots,K$

$$\frac{\partial L}{\partial \lambda}=m-\sum_{k=1}^{K}p_k x_k=0$$

$$\frac{MU_k}{p_k}=\frac{\partial u/\partial x_k}{p_k}=\lambda \qquad k=1,\ldots,K \quad\Rightarrow\quad \frac{MU_1}{p_1}=\frac{MU_2}{p_2}=\ldots=\frac{MU_K}{p_K}=\lambda$$

The consumer chooses purchases such that the ratio of marginal benefit (marginal utility) to marginal cost (price) is equal among all purchases

The ratio, with units of \$/unit of commodity or (shadow) price, is the Lagrange multiplier, the change in utility for a change in income $\lambda=\dfrac{\partial u}{\partial m}$

- **For 2 goods**

$$\frac{\partial u}{\partial x_1}-\lambda p_1=0$$

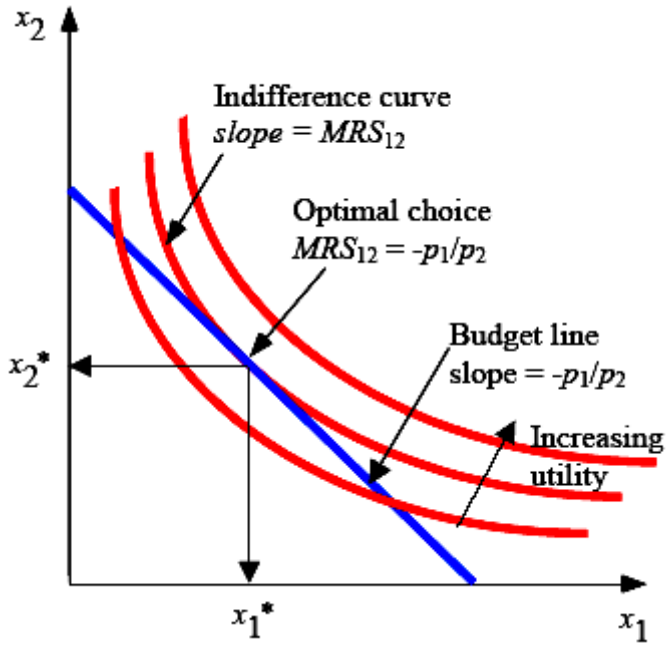
$$\frac{\partial u}{\partial x_2}-\lambda p_2=0$$

$$m-(p_1x_1+p_2x_2)=0$$

$$\Rightarrow\quad \frac{MU_1}{p_1}=\frac{MU_2}{p_2}=\lambda$$

Slope of budget line $Slope=-\dfrac{p_1}{p_2}$

Slope of indifference curve $Slope=\dfrac{dx2}{dx1}=-MRS_{12}$



At optimality (tangency point) - slope of budget line equals slope of indifference curve.

$$-\frac{p_1}{p_2} = \frac{dx_1}{dx_2} = -\frac{MU_1}{MU_2}$$

And ratio of marginal utilities equals ratio of prices

Demand

- **Demand function**

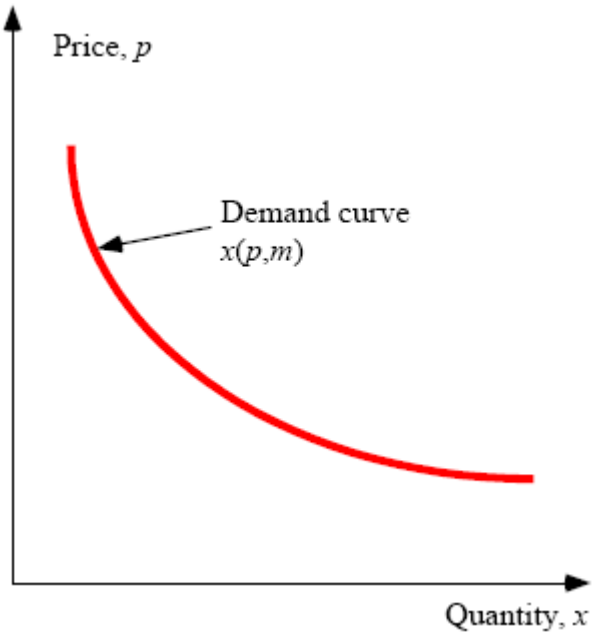
Optimal solution to consumer's problem depends on income and prices and gives the **DEMAND FUNCTION**

maximize $u(\boldsymbol{x})$

subject to

$\boldsymbol{p} \cdot \boldsymbol{x} \le m \quad \Rightarrow$ *solution* $\vec{\mathbf{x}}^* = \vec{\mathbf{x}}^*(\vec{\mathbf{p}}, \mathrm{m})$

$\boldsymbol{x} \ge 0$

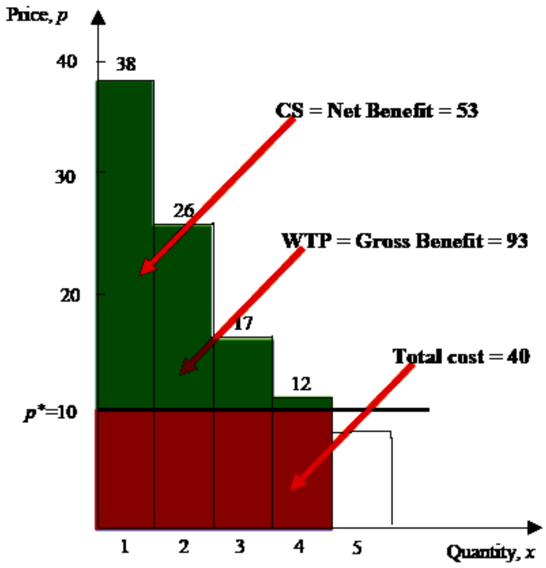


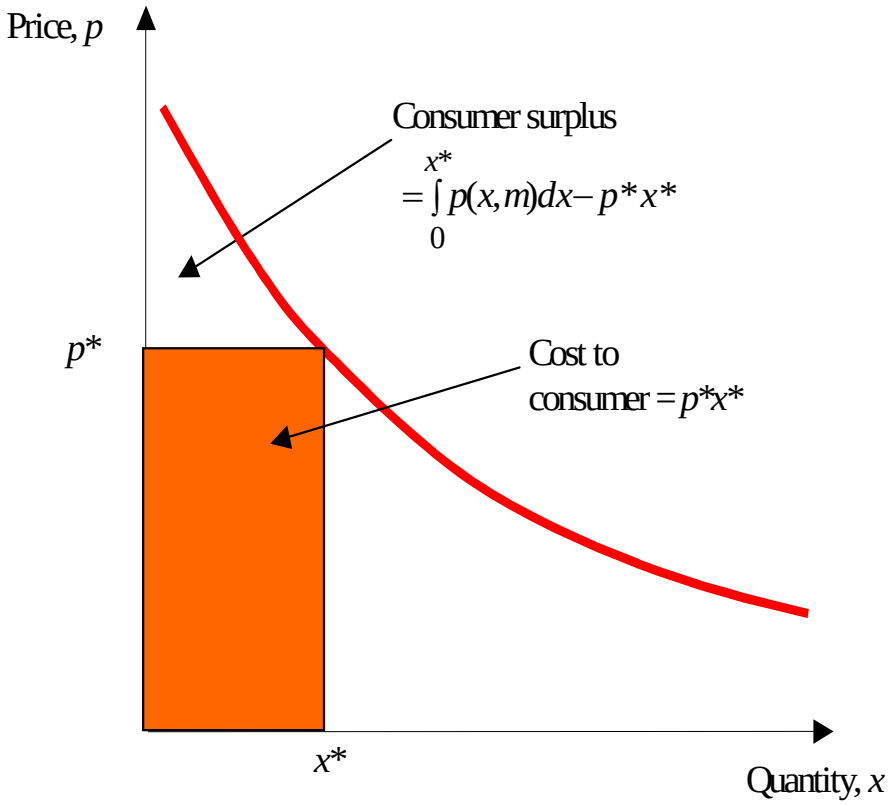
Value

- Value - worth, utility, or importance of something
  - Contribution to life support functions or commercial/recreational opportunities
  - Beauty
  - Uniqueness
  - Reducing environmental or human health risks
  - Irreplacability
  - Role in supporting wildlife
  - Providing many other services that benefit humans.
- Ecosystem values
  - Measures of how important ecosystem services are to people - What they are worth?

Willingness-to-Pay

- Value - What is someone willing to pay?
- Suppose farmer willing to pay for water:
  - First unit: $38
  - Second unit: $26
  - Third unit: $17
  - And so on
- If we charge
  *p** = $10
  - Farmer will purchase
    4 units for $40
  - But farmer is
    willing to pay $93
  - Farmer's Consumer surplus
    is $53





Measuring Benefits w/Market

- Need information on prices and quantities
- Derive demand curve
- Quantify willingness-to-pay
- Use WTP to represent benefits

Market Prices – Revealed WTP

- The values of some goods or services (including ecosystem services) can be measured using market prices.
    - Products traded in markets (e.g., fish, wood)
        - Values can estimated from consumer and producer surplus, as with any other market goods.
    - Ecosystem services used as inputs in production (e.g., clean water)
        - Value can be estimated from contribution to profits made from the final good.

- Some services (including ecosystem or environmental) may not be directly bought and sold in markets
- However, the prices people are willing to pay in markets for related goods can be used to estimate their values

    - People often pay a higher price for a home with an ocean view, or will take the time to travel to recreational places

    - These kinds of expenditures can be used to place a lower bound on the value of the view or the recreational experience.

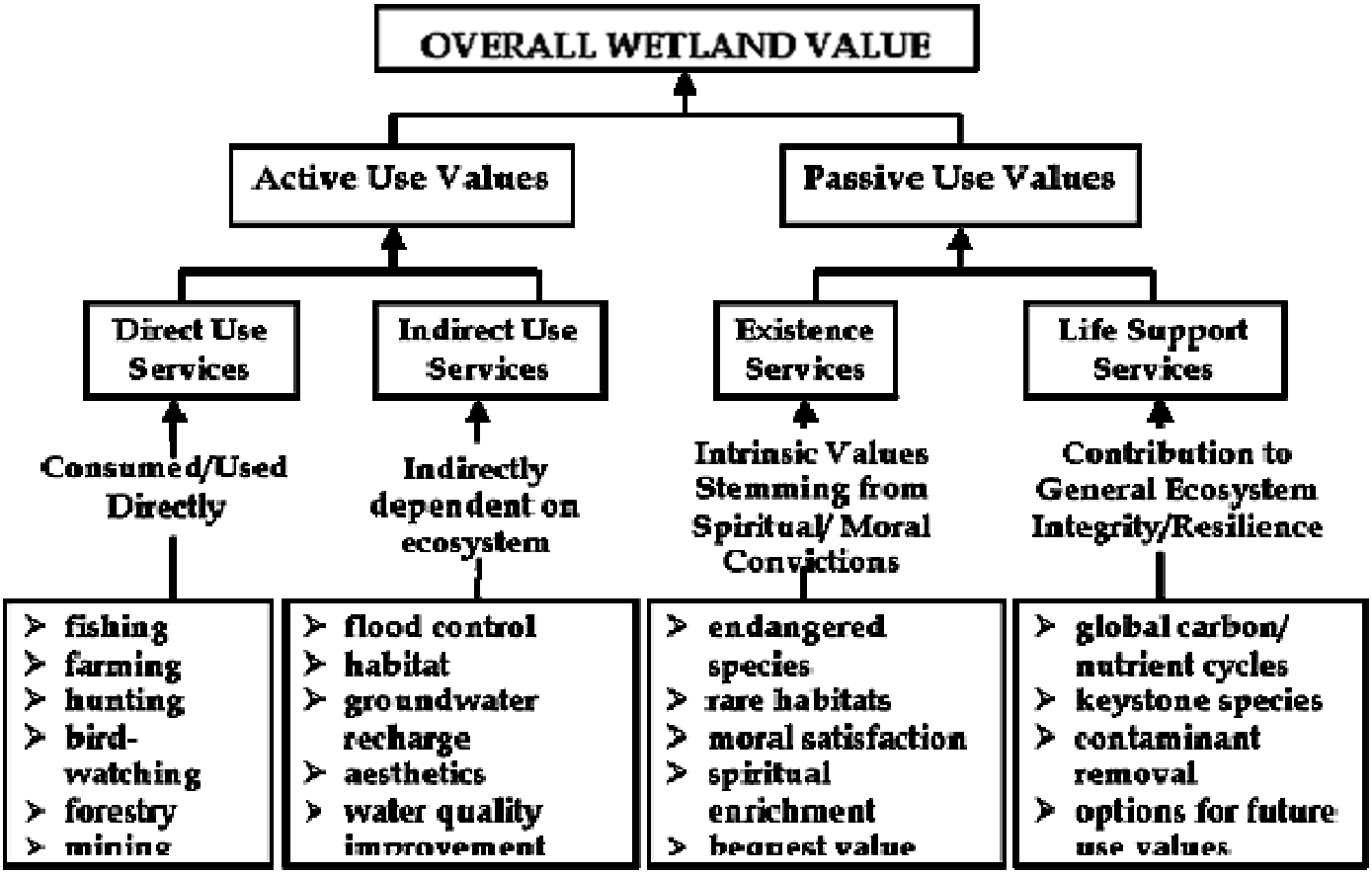
Methods using Market Prices

Estimate economic value of products, services, sites that …

- are bought and sold in commercial markets (Market Price Method)
    - *Commercial fishery & water pollution*
- contribute to the production of commercially marketed goods (Productivity Method)
    - *Reservoir holding Drinking water polluted by agricultural runoff*
- directly affect market prices of some other good (Hedonic Pricing Method)
    - *variations in housing prices that reflect the value of local environmental attributes*
- are used for recreation (Travel Cost Method)
    - *Assumes that the value of a site is reflected in how much people are willing to pay to travel to visit the site*

Circumstantial Evidence: Imputed WTP

- The value of some services can be measured by
    - estimating what people are willing to pay, or
    - the cost of actions they are willing to take to avoid adverse effects that would occur if these services were lost, or
    - to replace the lost services
- Example
    - Wetlands often provide protection from floodwaters.
    - $$ that people pay to avoid flood damage in areas similar to those protected by the wetlands
    - This can be used to estimate WTP for the flood protection services of the wetland



Methods using Circumstantial Evidence

- Estimate economic values based on costs of
  - avoided damages from lost services,
  - replacing ecosystem services, or
  - providing substitute services
- Examples
  - Improved water quality
    - Value = measure cost of controlling emissions
  - Erosion protection services of a forest or wetland
    - Value = cost of removing eroded sediment
  - Fish habitats
    - Value = cost of fish breeding and stocking programs

Surveys – Expressed WTP

- Many services are not traded in markets, and are not closely related to any marketed goods
- People cannot "reveal" what they are willing to pay for them through their market purchases or actions
- Methods
  - Contingent Valuation Method (CVM)

    - Ask people to directly state their WTP for specific services, based on a hypothetical scenario
  - Contingent Choice Method (CCM)
    - Ask people to make tradeoffs among sets of services or characteristics
    - Does not directly ask for WTP — this is inferred from tradeoffs that include cost as an attribute

Summarizing – Measuring Benefits w/o Market

- Prices may not exist
- Demands may not be revealed, and
- Change in benefits over time may be extremely uncertain,
- For example
  - Benefits of preserving space for recreation
  - Benefits from damages prevented due to pollution controls
- Sometimes
  - Damages of pollution can be identified and estimated
  - Surveys determine willingness-to-pay for environmental preservation, damage reductions, lower risks, etc
  - Survey results infer values (benefits)

Why estimate *ecosystem* values?

- To decide how to allocate spending on conservation, preservation, or restoration initiatives

- To consider stakeholder values, and encourage stakeholder participation and support for initiatives

- To compare benefits of different projects or programs

- To prioritize projects

Types of ecosystem values

- Use values ("active use" values)
  - Based on actual use of the environment
  - Hunting, fishing, hiking, etc.
- Non-use values ("passive use" values)
  - Not associated with actual use of, or even an option to use, an ecosystem or its services
  - Existence value (River preservation)
  - Option value
    - value of having the option to enjoy in the future

- Bequest value
  - value of knowing future generations will have the option to enjoy

Measures of Ecosystem Values

- Relative "value" of two things
  - Maximum amount of one thing a person is willing to give up to get more of another thing

- Ecosystem values
  - How much purchasing power people
    - are willing to give up to get it
    - or would need to be paid to give it up, if they were forced to make a choice
  - This situation may never occur in the “real world”.

Challenges of Ecosystem Valuation

- Non-Market Goods
  - Most environmental goods (e.g., clean air and water, and healthy fish and wildlife populations) are not traded in markets and their value is not revealed in prices
- Public Goods
  - Many environmental goods can be enjoyed by everyone (similar to broadcast radio and television)
- Non-exclusive Goods
  - Many environmental benefits are non-exclusive (everybody benefits)
  - Free rider problem makes it impractical to recoup cost of on-site investments from those who benefit off-site
- Inseparable Goods
  - Investments at a given site may result in benefits over great distances in time and space
  - It may be impossible to separate the economic benefits that result from one conservation practice from those at another site
  - Also, it may be impossible to separate the aggregate benefits of those practices from those of other environmental investments