# 1.201: An Introduction

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1.201 / 11.545 / ESD.210
Transportation Systems Analysis: Demand & Economics

Fall 2008

# Outline

1. Context, Objectives, and Motivation
2. Introduction to Microeconomics
3. Introduction to travel demand
4. Course Structure

# Context for Transportation Systems Analysis

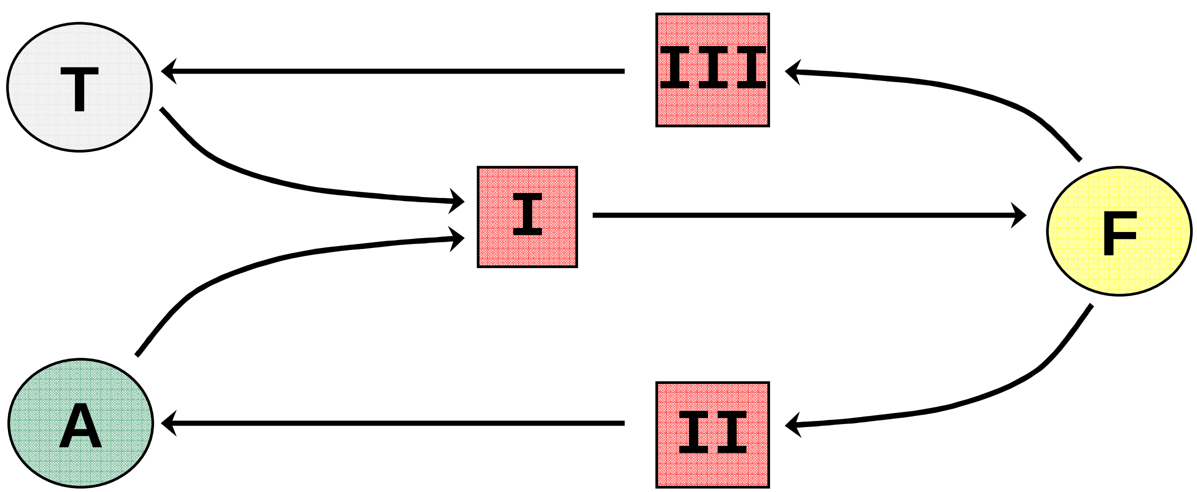
- Conceptual View of TSA
- Models and Prediction
- Prediction in Context: Analysis and Implementation

Source: Manheim, M, *Fundamentals of Transportation Systems Analysis*, 1979

# A Conceptual View of TSA

3 elements in transport system problems:

- Transport system, *T*
- Activity system, *A*
- Flow pattern, *F*




Source: Manheim, M, *Fundamentals of Transportation Systems Analysis*, 1979

# A Conceptual View of TSA

3 types of inter-relationships:

Type I: *Flow* determined by both *Transport* and *Activity* systems

- the short-run "equilibrium" or outcome
- many problems are dynamic rather than static

Type II: *Flow* pattern causes change over time in the *Activity* system through services provided and resources consumed

Type III: *Flow* pattern also causes changes over time in the *Transport* system

- transport operator adds service on a heavily-used route
- new highway link constructed

Source: Manheim, M, *Fundamentals of Transportation Systems Analysis*, 1979

# Models and Prediction

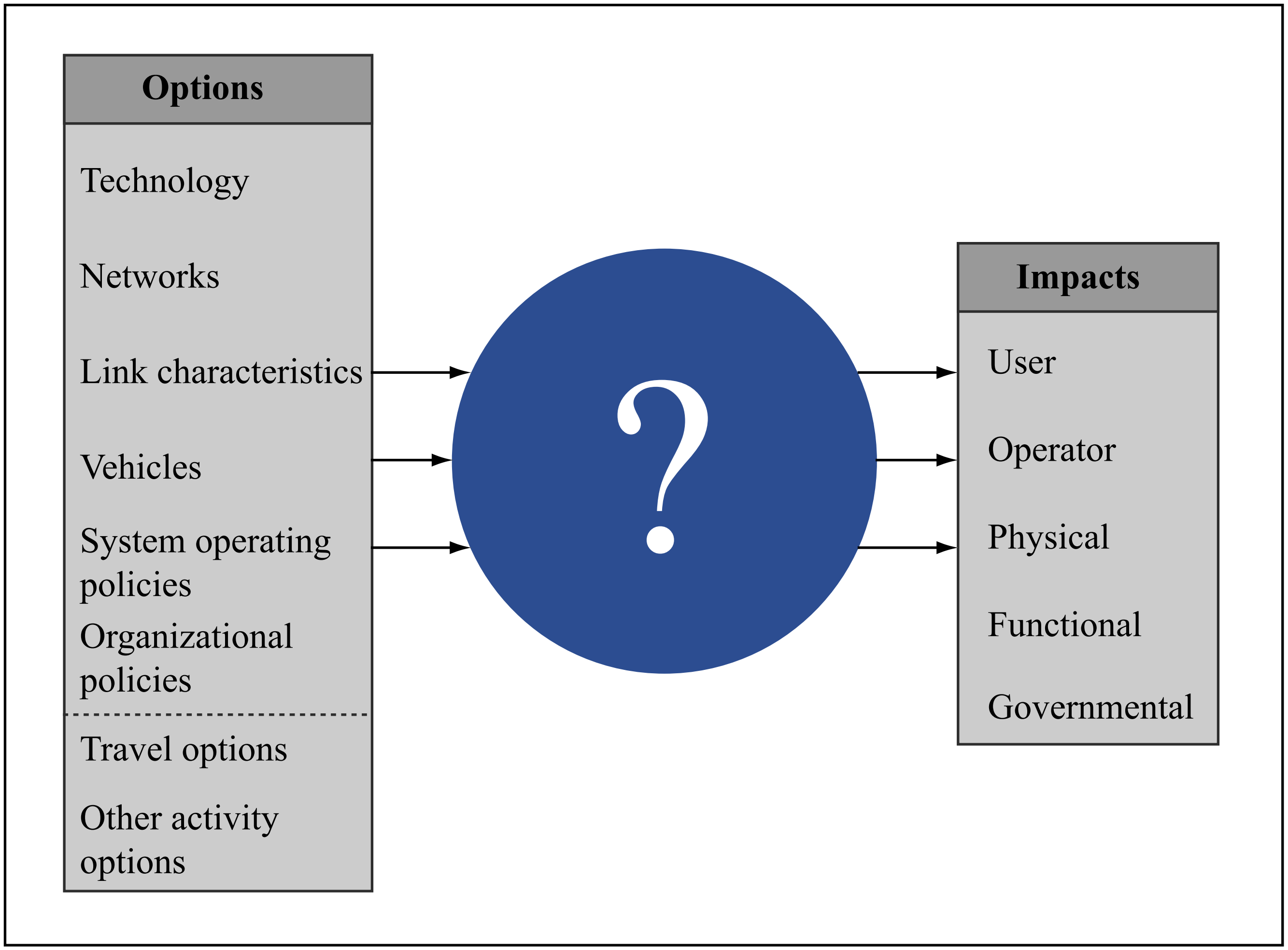



Figure by MIT OpenCourseWare.

Source: Manheim, M, *Fundamentals of Transportation Systems Analysis*, 1979

# Models and Prediction

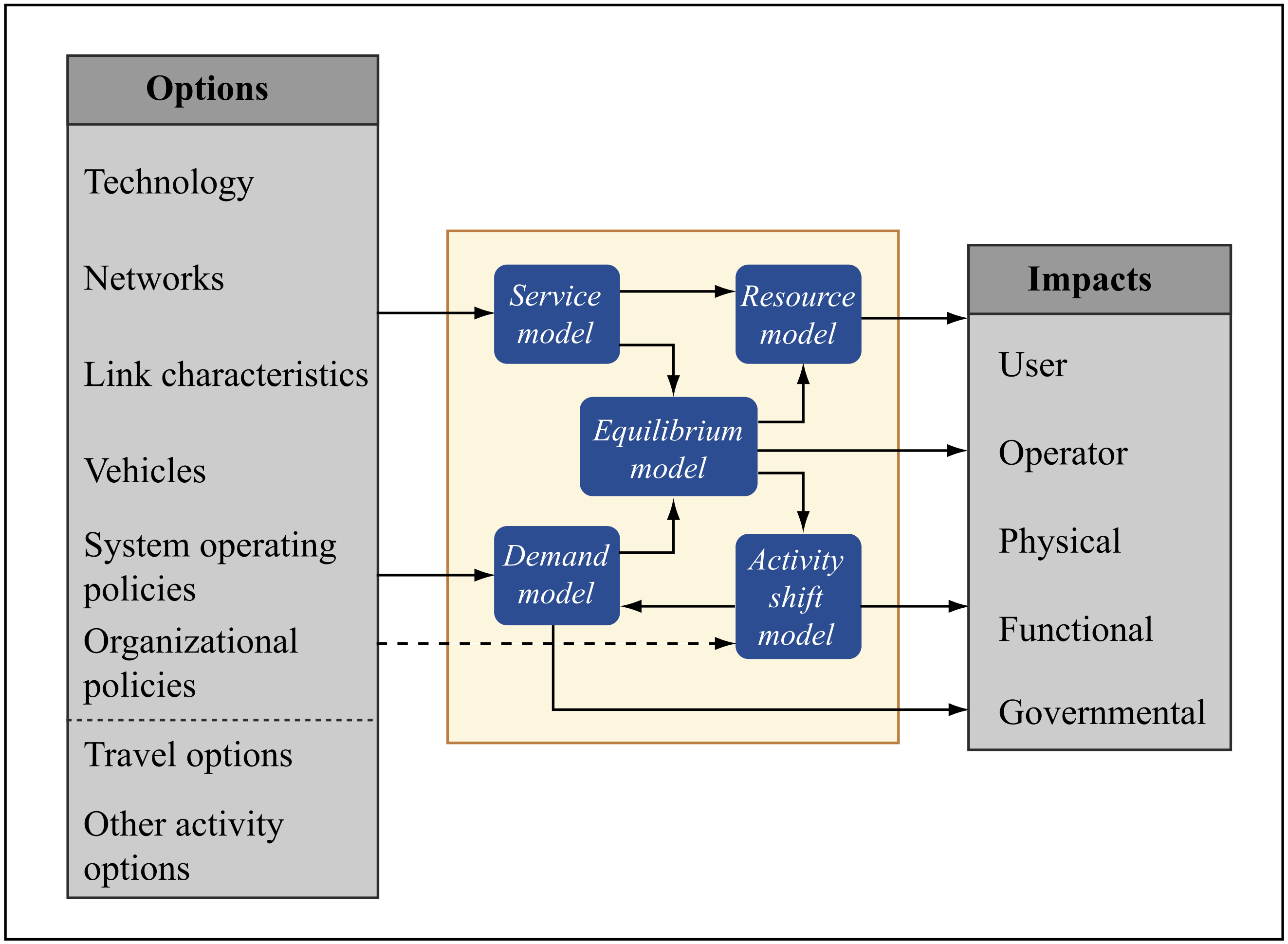



Figure by MIT OpenCourseWare.

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# Prediction in Context

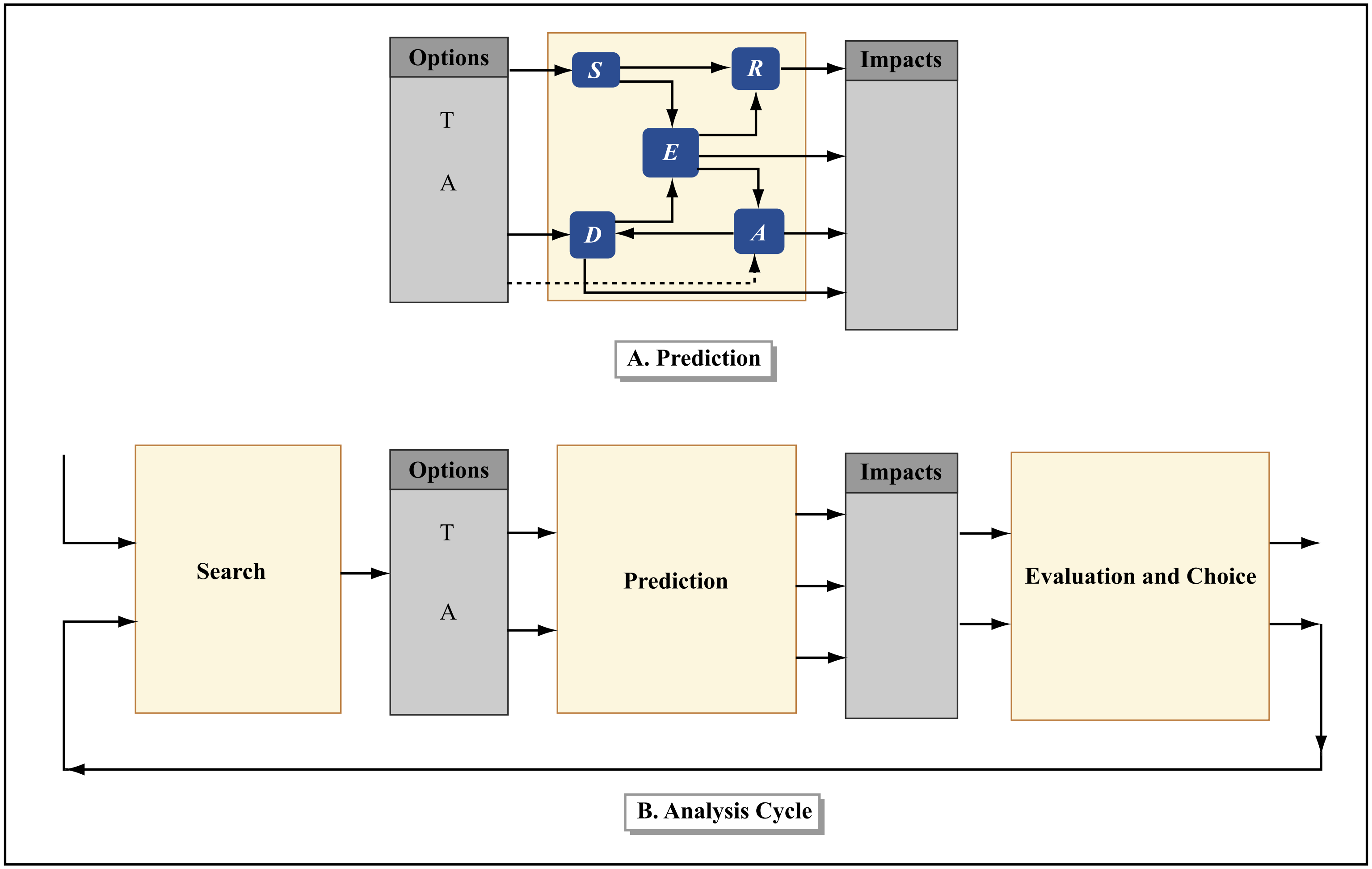



Figure by MIT OpenCourseWare.

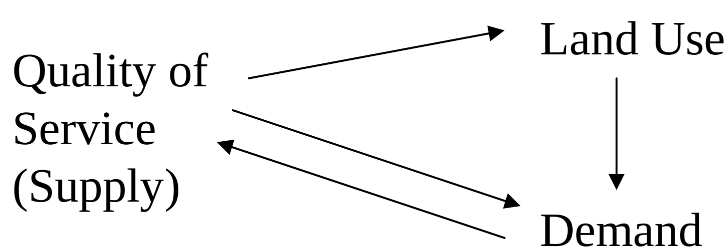
Source: Manheim, M, *Fundamentals of Transportation Systems Analysis*, 1979

# Objectives of this Course

- Build the economic framework to analyze the supply and demand for transportation
- Develop methodologies for predicting transportation demands and costs
- Demonstrate how principles of economics can be applied within the context of transportation systems to understand the effects of different plans and policies

# Why Study Transportation Economics? (I)

- Example 1: High-Speed Rail
  - Has been successful in Japan, China, and some European countries, but no experience in the US
  - Is the demand going to be sufficient to justify the high costs?
  - Demand forecasting is complicated



# Why Study Transportation Economics? (II)

- Example 2: Traffic Jams
  - Building more highways
  - Intelligent Transportation Systems
  - Encouraging transit ridership
  - Pricing

# Why Study Transportation Economics? (III)

- Example 3: Trucks in the Alpine Valleys
  - Highways in narrow valleys trap noise and exhaust fumes from the trucks
  - In 1994, Swiss voters decided to close highways to truck traffic beginning in 2004
  - How should one evaluate this decision?
  - What are the benefits and costs of this decision?
  - How to compare costs to the trucking firms with the environmental impacts?

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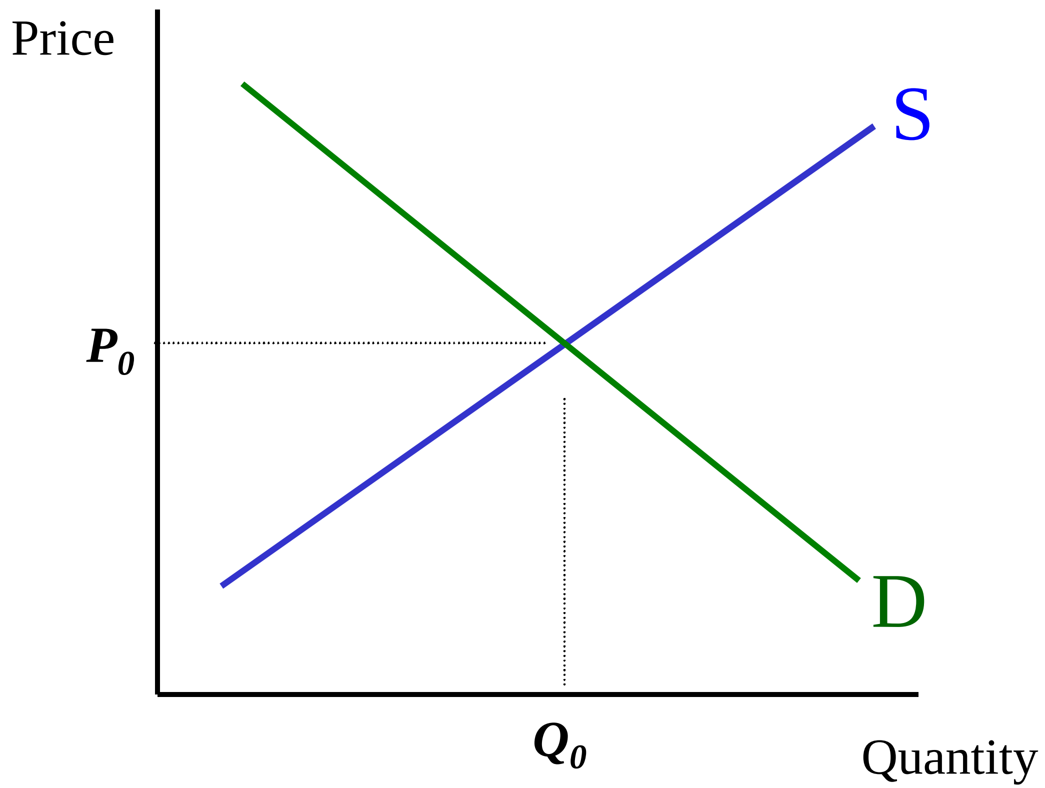
# What Is Microeconomics?

- Branch of economics that deals with the behavior of individual economic agents – consumers, firms, worker, and investors – as well as the markets that these units comprise.

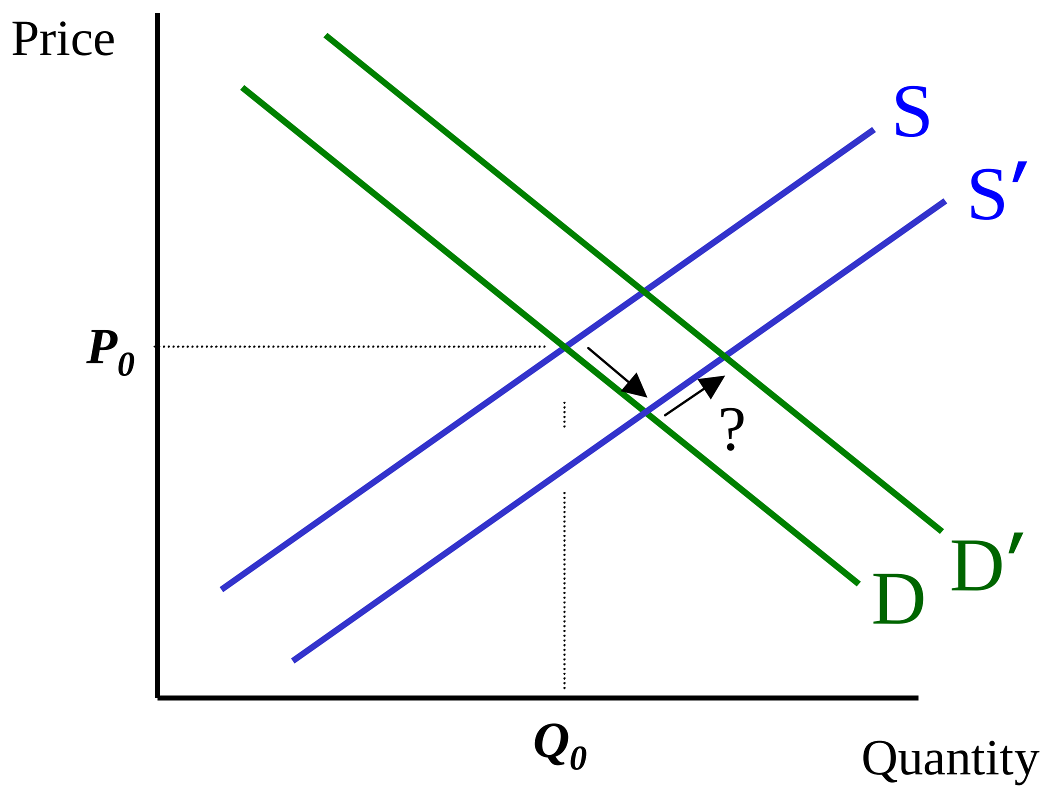
# Demand and Supply

- Market demand function
  - Represents behavior of users
- Market supply function
  - Represents congestion and behavior of service providers
- Supply/Demand Interaction: Equilibrium

# Equilibrium



# Shifting Curves



# Comparative Statics

- Create a *model* of market behavior:
  - Explain consumer and firm choices as a function of exogenous variables, such as income and government policy
- Develop scenarios:
  - Changes in exogenous variables
- Derive changes in the endogenous variables

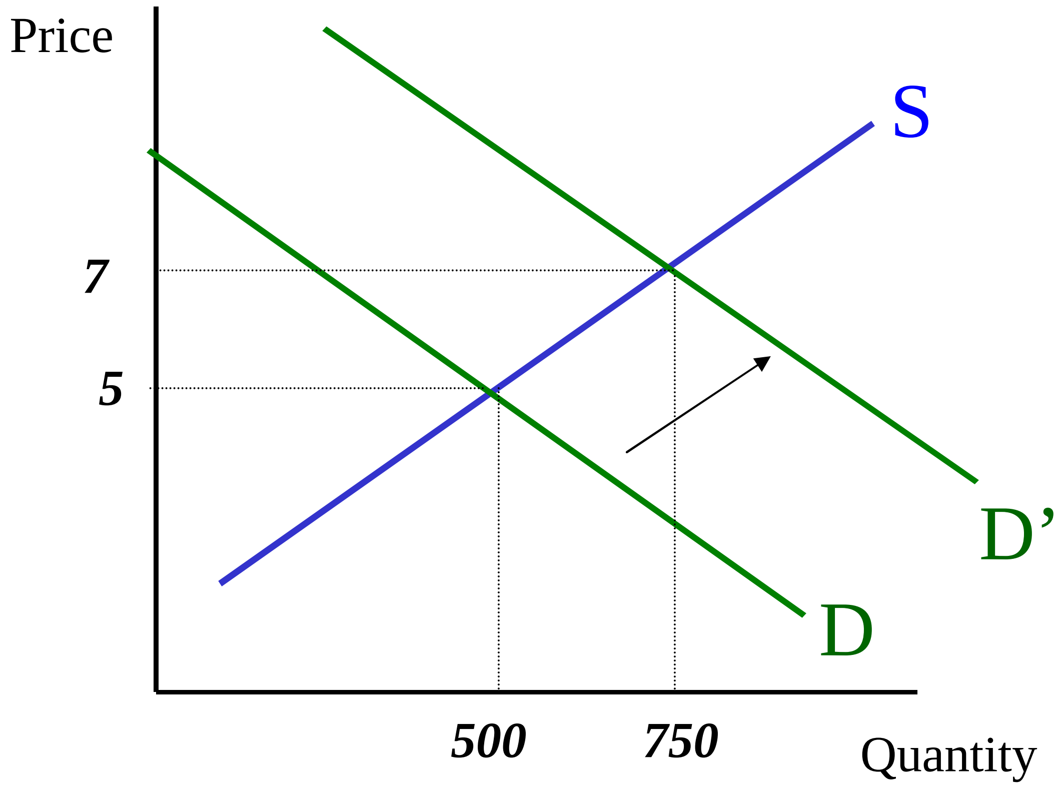
# Comparative Statics Example

The market for taxi service:

- Supply model: $Q_S = -125 + 125P$
- Demand model: $Q_D = 1000 – 100P$
- Where does the market clear?

- What happens if demand shifts such that now $Q_D = 1450 – 100P$ ?

# The Solution



# Consumer Behavior

**How do we characterize a consumer?**

- Preferences across goods
- Prices of goods
- Budget available to spend on those goods

# Utility Function

- A function that represents the consumer's preferences ordering

  $U = f(x_1, x_2, \ldots, x_m)$

  Consumption levels of goods 1..m

- Utility functions give only an *ordinal* ranking:
  - Utility values have no inherent meaning
  - Utility function is not unique
  - Utility function is unaffected by monotonic transformation

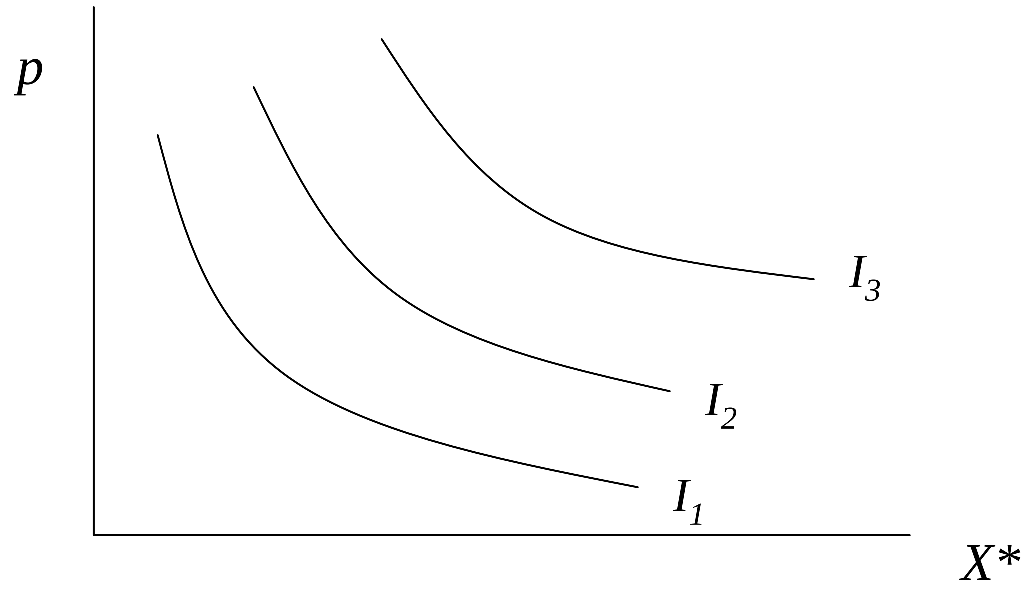
# Consumer Behavior

- Assumed behavior by consumer: utility maximization subject to budget constraints
- When facing prices ***p*** and having income ***I***, consumer allocates income across goods so as to maximize utility.
- Problem: *Max* $U(x_1,\ldots, x_m)$ *subject to*

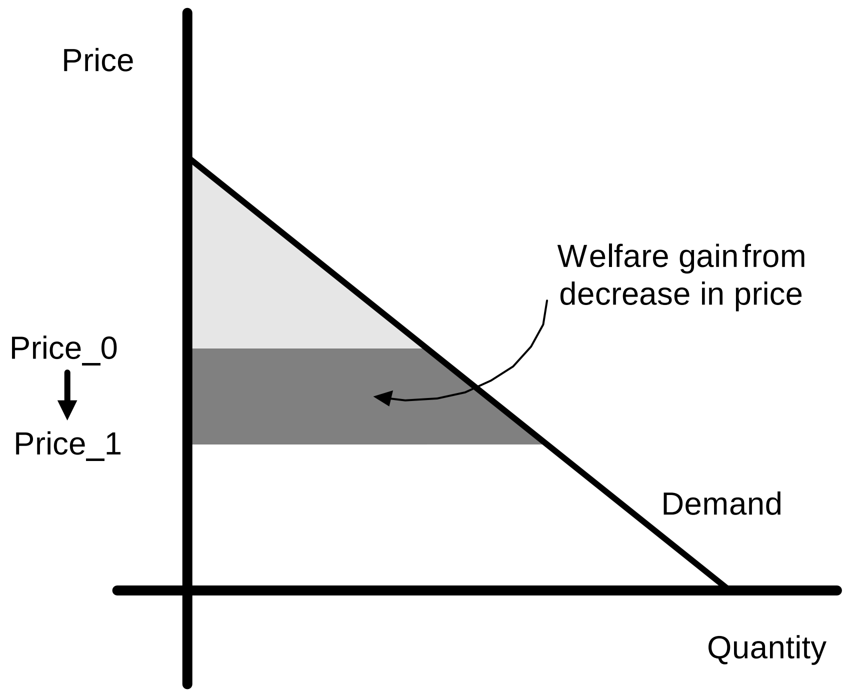
$$\sum_{i=1}^{m} p_i x_i \leq I$$

# Demand Function

- Optimal consumption bundle *X**
- By varying price *p* and income *I* and solve for *X**, we derive the *demand function X*(p, I)*



# Consumer Welfare



# Firm Behavior

**How do we characterize a firm?**

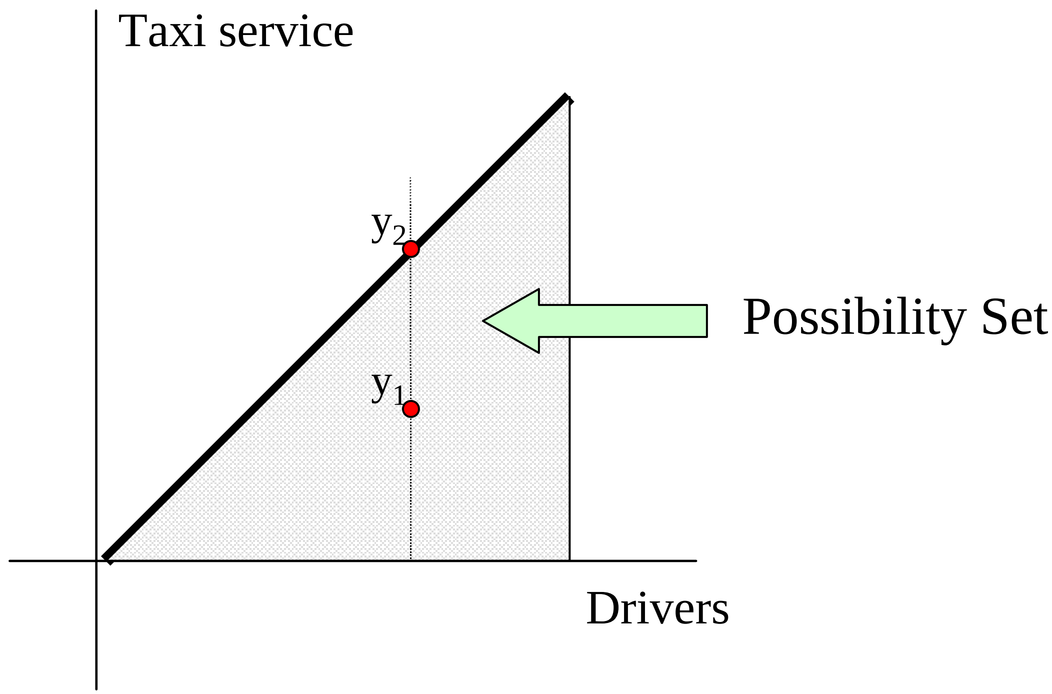
- The technology and inputs for creating products
- The prices of the required inputs
- The demand for the firm's product(s)

# Production

- Technology: method for turning inputs (including raw materials, labor, capital, such as vehicles, drivers, terminals) into outputs (such as trips)
- Production Possibility Set: quantities of output possible given levels of input

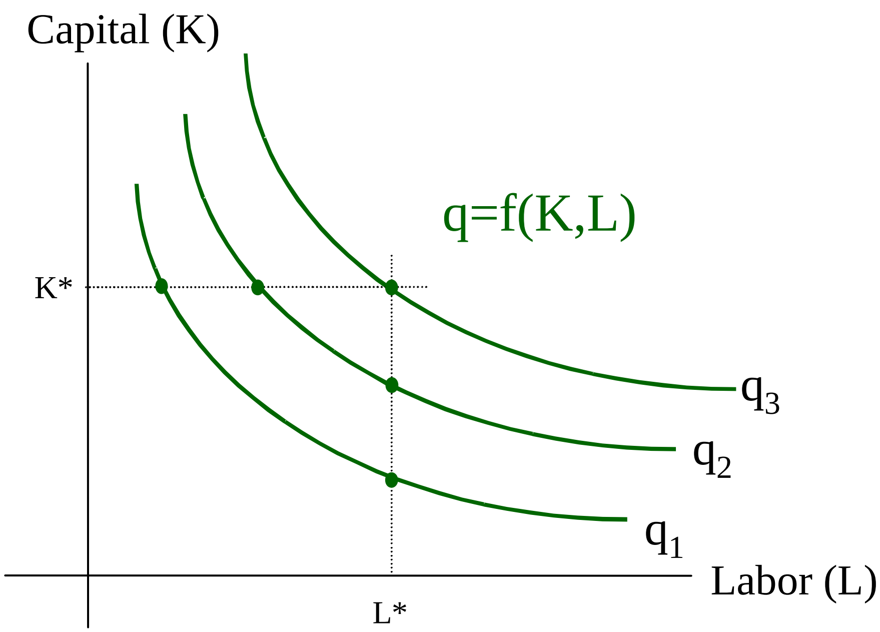
# Possibility Set

- The firm may choose to produce any element in its production possibility set
- Example: taxi services and drivers



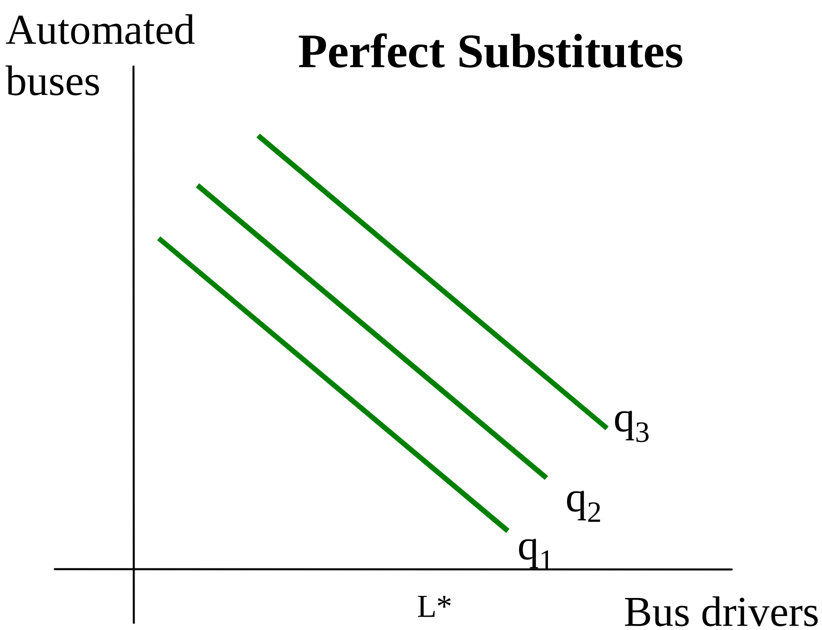
# Production Functions

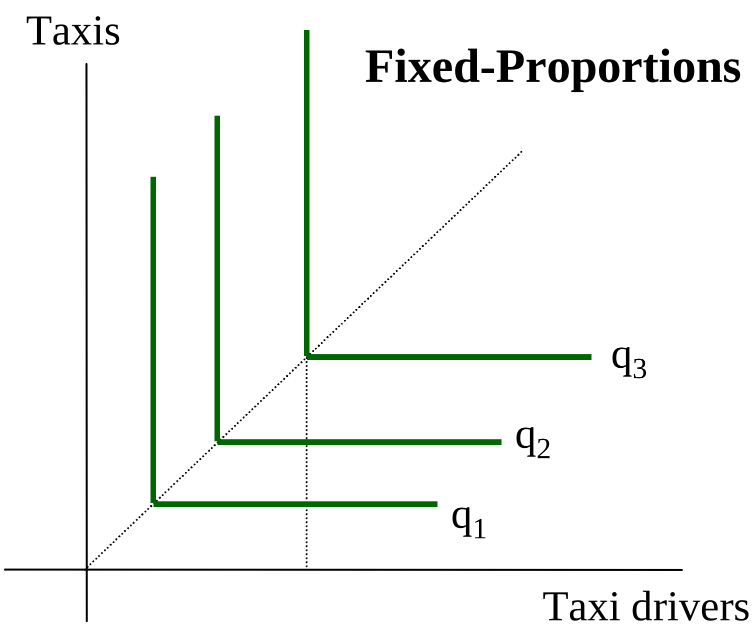
- Simplified form: $q = f(\boldsymbol{z})$
  - $q$: output; $\boldsymbol{z}$: inputs
- Isoquants for two-input production:



# Production Functions

- Does the technology allow substitution among inputs or not?



# Cost Functions

- Now consider input price vector ***w***.
- Assume efficient behavior by firm: produce output *q* for the lowest possible cost.
- Therefore, cost function is:

$$c(\mathbf{w},q) = \min_{\mathbf{z}} \mathbf{w}\cdot\mathbf{z}$$

$$\textbf{subject to } q = f(\mathbf{z})$$

- This function describes the cost of producing any feasible level of output.

# Firm Objective

- Maximize profit
- Maximize revenue when cost is fixed
- Minimize cost when prices are fixed

# Profit Maximization

- Firm maximizes: profit = revenue - cost

$$\pi(q) = p \cdot q - c(q)$$

- General result: MR($q$) = MC($q$)

  MR: marginal revenue

  MC: marginal cost

- For a competitive firm, $p$ is fixed
  - MR = $p$
  - Quantity supplied is determined such that MC = $p$

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# Transportation Demand Analysis

- Use models to understand complex processes
  - Transit ridership
  - Sprawl
  - Congestion pricing
  - Traveler information systems
  - Jobs-housing balance
- Assist decision making

# Choices Impacting Transport Demand

- Decisions made by Organizations
  - Firm locates in Boston – Firm locates in Waltham
  - Firm invests in home offices, high speed connections
  - Developer builds in suburbs – Developer fills in in downtown
- Decisions made by Individual/Households
  - Live in mixed use area in Boston – Live in residential suburb
  - Don't work – Work (and where to work)
  - Own a car but not a bike – Own a bike but not a car
  - Own an in-vehicle navigation system
  - Work Monday-Friday 9-5 – Work evenings and weekends
  - Daily activity and travel choices:
    what, where, when, for how long, in what order, by which mode and route, using what telecommunications

# Discrete Choice Analysis

- Method for modeling choices from among discrete alternatives
- Components
  - Decision-makers and their socio-economic characteristics
  - Alternatives and their attributes
- Example: Mode Choice to Work
  - Decision maker: Worker
  - Characteristics: Income, Age
  - Alternatives: Auto and Bus
  - Attributes: Travel Cost, Travel Time

# Role of Demand Models

- Forecasts, parameter estimates, elasticities, values of time, and consumer surplus measures obtained from demand models are used to improve understanding of the ramifications of alternative investment and policy decisions.
- Many uncertainties affect transport demand and the models are about to do the impossible

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# Structure of This Course

- Alternating:
  - Theory:
    - Demand, Costs, Pricing, Revenue, Project Finance, Project Evaluation
  - Applications:
    - Public Transportation, Maritime, Aviation, Developing Countries, ITS

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