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Market for Lemons

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Let’s play a game !

Game

- Half of all used cars are “lemons”
  - Value to seller (current owner) = 0
  - Value to buyer = 100
- Half of all used cars are “peaches”
  - Value to seller = 200
  - Value to buyer = 300
- Information
  - Only the seller knows if the car is a lemon or a peach
- Game
  - A broker suggests the price P
  - The buyer and the seller say ”yes” or ”no” simultaneously
  - Only if both say ”yes” the good will be traded

Game

- Procedure
  - Form pairs
  - Sellers come forward to collect information about their cars – Check information secretly!
  - I am broker and will suggest a price
  - Both seller and buyer write down your choice on a piece of paper - Secretly

Price announcement

- Half of all used cars are "lemons"
  - Value to seller (current owner) = 0
  - Value to buyer = 100
- Half of all used cars are "peaches"
  - Value to seller = 200
  - Value to buyer = 300
- Price:

Result?

Interpretation

Analysis

- Q1: How many cars should be sold, from an efficiency point of view?
  - All !
    - Buyers value peaches higher than Sellers
    - Buyers value lemons higher than Sellers

Analysis

- Q2: How many cars would be, according to economic reasoning?
  - Difficult, let's check !

Interpretation

- Seller's value
  - If peach = 200
  - If lemon = 0
- Price 125
- Q: Seller's choice?
  - If peach: keep
  - If lemon: sell
- Q: Buyer's expected value of buying?
  - 100 (= 0 · 300 + 1 · 100)
- Q: Buyer's choice?
  - don't buy
- Conclusion: Market brakes down!

Probability a car for sale is a peach

Buyer's valuation of peach

Information

- Imperfect information
  - Agents do not observe all previous behavior (or simultaneous moves)
  - Example: Firms decide on price simultaneously
- Incomplete information
  - Agents do not know all the exogenous data
  - Example: Firms may not know demand
- Asymmetric information
  - Some players know some exogenous data (= private information)
  - Others don't

Asymmetric Information

- Examples
  - Firms may not know each other's costs
  - Firms may not know consumers' willingness to pay
  - Consumer may not know quality of good
  - Employers may not know the productivity of an applicant
  - Banks may not know the bankruptcy risk of entrepreneurs
  - Insurance company may not know risk that a person falls ill
  - Governments may not know firms' costs of reducing polution

Asymmetric Information

- But: Learning
  - Often people disclose some of their private information when they act
  - Others will learn
- How do we model learning?
  - Bayesian updating

Baye’s Rule

Baye’s Rule

- Example of asymmetric information
  - Entrepreneurs
    - Some but not enough money to finance their projects
    - They know relatively well if their project will succeed or fail
  - Banks don’t know the if a new firm will succeed
    - If the project succeeds => Entrepreneur is able to pay the loan
    - If the project fails => Bankruptcy

Baye's Rule

- Question
  - How can banks learn about the entrepreneurs' private information?
- Answer
  - If the entrepreneur believes the project will succeed, he is willing to risk his own money.
  - Otherwise not.

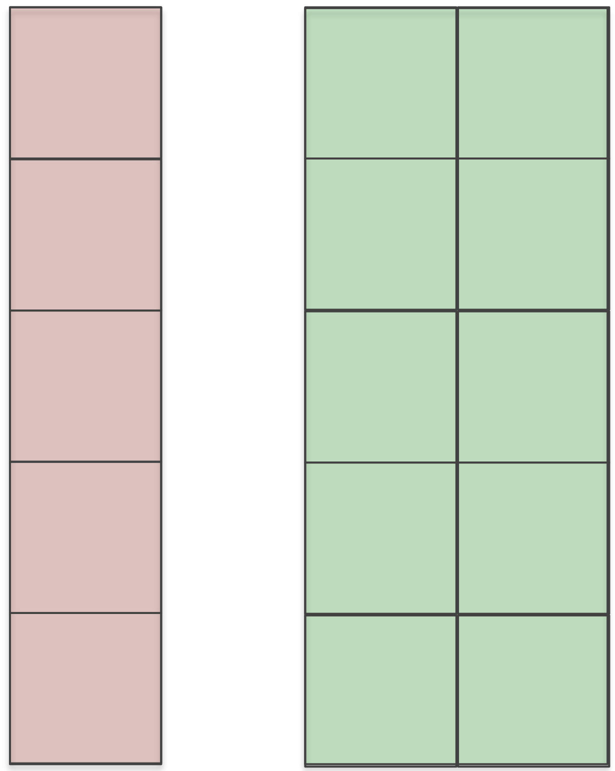
Baye's Rule

- Numeric example
  - Two types of entrepreneurs
    - 5 with good projects
    - 10 with bad projects
  - Among entrepreneurs with good projects 80 % believe the project is good and are willing to risk their own wealth
  - Among entrepreneurs with bad projects 10 % believe that the project is good and are willing to risk their own wealth

Baye's Rule

Population

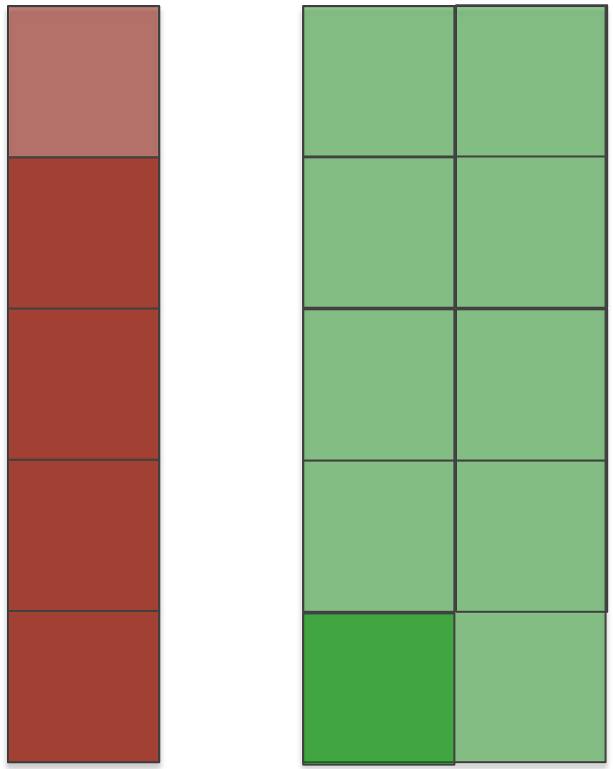
- 5 entrepreneurs with good projects
- 10 entrepreneurs with bad projects



Baye’s Rule

Population

- 5 entrepreneurs with good projects
  - -80% willing to risk own money
- 10 entrepreneurs with bad projects
  - -10% willing to risk own money



Baye's Rule

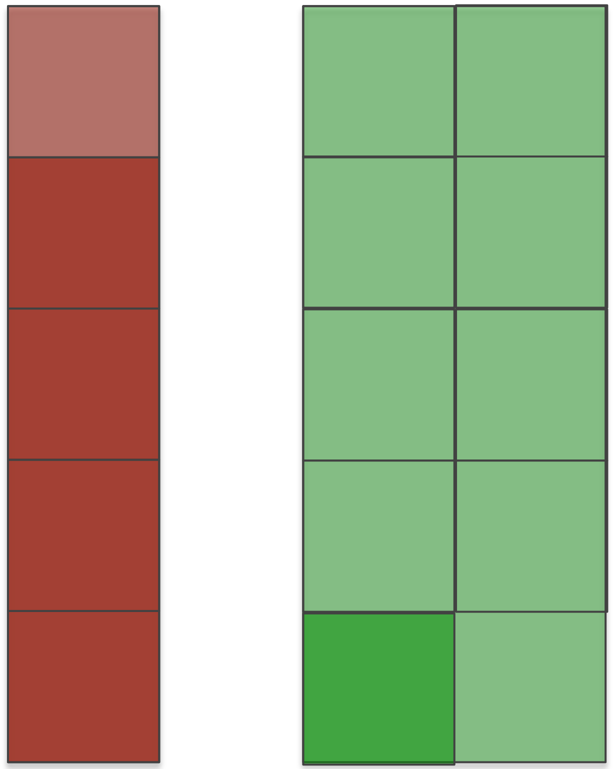
Population

- 5 entrepreneurs with good projects
  - -80% willing to risk own money
- 10 entrepreneurs with bad projects
  - -10% willing to risk own money

Exercises

What is the probability that a random entrepreneur has good project?

1. In population
2. Among those with some own funding
3. Among those without own funding



Baye's Rule

Population

- 5 entrepreneurs with good projects
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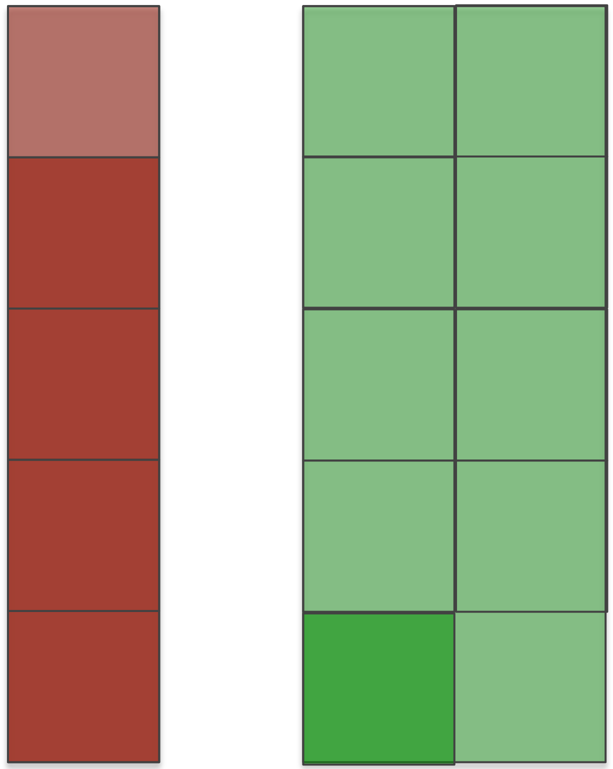


Answers

1. 5 out of 15 (33%) entrepreneurs in population are profitable.
2. 4 out of 5 entrepreneurs (80%) with some funding are profitable.
3. 1 out of 10 entrepreneurs (10%) without funding are profitable.

Baye's Rule

- Conclusion
  - By *observing* loan applicants *behavior* (how much of their own money they are willing to risk) a bank may *learn* something about their *private information* (probability of success).

Baye's Rule

- Example
  - An employer doesn't know the productivity of job applicants
  - Two types of applicants
    - 500 with high productivity
    - 500 with low productivity
  - Among people with high productivity 90 % invest in a master
  - Among people with low productivity 10 % invest in a master
- Exercise 1
  - What is the probability that a job applicant with a master has high productivity?

Baye’s Rule

- Solution 1
  - Number of high-productive that invest in master 450 = 0.9 * 500
  - Number of low-productive that invest in master 50 = 0.1*500
  - Total number of people with master 500 = 450 + 50
  - Share of people with master that are high-productive 0.9 = 450/500
- Note
  - Share of high productive in population 50 % < 90 %

Baye’s Rule

- Example
  - An employer doesn’t know the productivity of job applicants
  - Two types of applicants
    - 500 with high productivity
    - 500 with low productivity
  - Among people with high productivity 90 % invest in a master
  - Among people with low productivity 10 % invest in a master
- Exercise 2
  - What is the probability that a job applicant *without* a master has high productivity?

Baye's Rule

- Solution 2
  - Number of high-productive without master 50 = 0.1 * 500
  - Number of low-productive without master 450 = 0.9*500
  - Total number of people without master 500 = 50 + 450
  - Share of people without master that are high-productive: 0.10 = 50/500

- Note
  - Share of high productive in population: 50 %
  - Share of high productive among people with master: 90 %
  - Share of high productive among people without master: 10 %

Baye's Rule – More Generally

- Population shares
  - P(H) = share of people with high productivity in population
  - P(L) = share of people with low productivity in population
- Behavior
  - P(M:H) = likelihood of getting master, if high productive
  - P(M:L) = likelihood of getting master, if low productive
- Exercise
  - Find expression for P(H:M) = probability of being high prod. if master

$$P(H:M) = \frac{\Pr\{Master \,\&\, High\}}{\Pr\{Master\}} = \frac{P(H)\cdot P(M \mid H)}{P(H)\cdot P(M \mid H) + P(L)\cdot P(M \mid L)}$$

$$= \frac{\frac{1}{2}\cdot\frac{9}{10}}{\frac{1}{2}\cdot\frac{9}{10} + \frac{1}{2}\cdot\frac{1}{10}} = \frac{9}{9+1}$$

Baye's Rule

- Q: What happens if P(M|H) = P(M|L)
- Answer

$$P(H \mid M) = \frac{P(H)\cdot P(M \mid H)}{P(H)\cdot P(M \mid H) + P(L)\cdot P(M \mid L)}$$

$$= \frac{P(H)}{P(H) + P(L)}$$

$$= P(H)$$

- If people with high productivity and low productivity are equally likely to get education, employers don't learn anything by observing education

Baye's Rule

- Example
  - An employer doesn't know the productivity of job applicants
  - Two types of applicants
    - 500 with high productivity, solve 10 problems per hour
    - 500 with low productivity, solve 2 problems per hour
  - Among people with high productivity 90 % invest in a master
  - Among people with low productivity 10 % invest in a master
- Exercise 3
  - What is the expected productivity in the population?
  - What is the expected productivity among people with master?
  - What is the expected productivity among people without master?

Baye's Rule

- Recall
  - Share of high productive in population: 50 %
  - Share of high productive among people with master: 90 %
  - Share of high productive among people without master: 10 %
- Expected productivity
  - Population: 0.5 * 10 + 0.5 * 2 = 6
  - Master: 0.9 * 10 + 0.1 * 2 = 9.2
  - Without: 0.1 * 10 + 0.9 * 2 = 2.8

Baye's Rule

- Education is a signal of productivity
  - IF: Different productivity => Different probability to get master
  - THEN: Master is signal of productivity
- Signal provides valuable information
  - Employers who cannot observe productivity directly
  - Can base hiring decision or wage on education
  - Must use Baye's rule

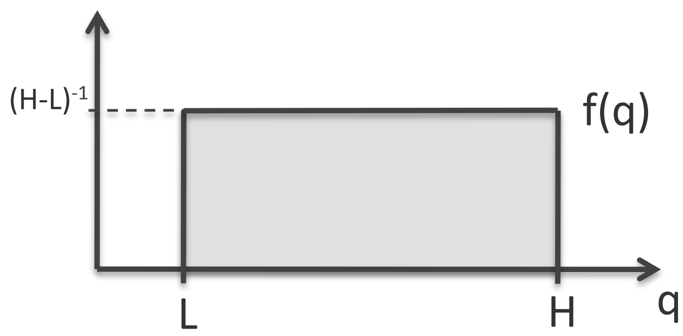
Market for Lemons

Market for Lemons

- Basic point
  - Asymmetric information about quality may disrupt a market
- Intuition
  - Buyers don't observe quality of (say) used cars
  - IF: Price = 100
  - THEN: Only cars with quality below 100 will be supplied
  - THEN: Average value of cars actually supplied is low, say 50
  - THEN: Buyers only willing to pay 50
- But
  - If buyers and sellers have sufficiently different valuations of quality, the information problem may be partly overcome

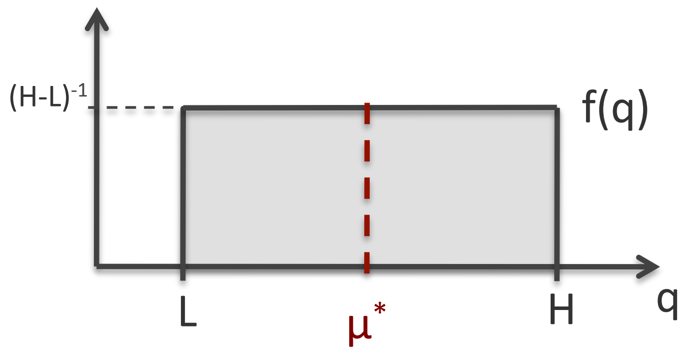
Market for Lemons

- Used cars
  - Mass 1 of sellers with one car each
  - Quality uniformly distributed over [L, H]



Market for Lemons

- Expected quality in population

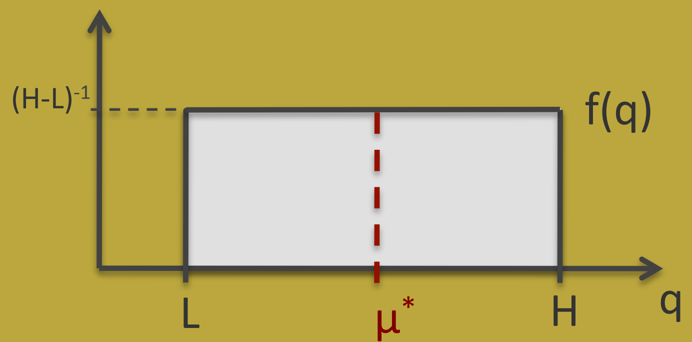


Uniform distribution => Average ="mid point"

$$\mu^* = \frac{H+L}{2}$$

Market for Lemons

- Expected quality



$$\mu^* = Eq = \int_L^H f(q)\cdot q\cdot dq = \int_L^H \frac{1}{H-L}\cdot q\cdot dq$$

$$\mu^* = \frac{1}{H-L}\int_L^H q\cdot dq = \frac{1}{H-L}\left[\frac{1}{2}q^2\right]_L^H = \frac{1}{H-L}\frac{1}{2}\left[H^2-L^2\right] = \frac{1}{H-L}\frac{1}{2}[H-L][H+L] = \frac{H+L}{2}$$

Market for Lemons

- Information
  - Buyers cannot observe quality
- Note
  - Equilibrium price must be the same for all cars
  - All sellers claim they have high quality
- Otherwise perfect competition
  - Continuum of buyers and sellers
  - Both buyers and sellers are price-takers

Buyers

Buyers

Two possible reasons:
- Buyers compute the equilibrium
- Buyers know average quality from own and friends experience

- Buyers
  - Identical
  - Mass = 1
- Utility
  - without car: m (income)
  - with car: $\Theta_B q + m - p$ (q = quality)
- Uncertainty
  - Know average quality for sale: μ (Baye's rule)
  - Risk-neutral
- Demand
  - Buy iff: $\Theta_B \mu \geq p$

Buyers

- Market demand

$$D = \begin{cases} 0 & p > \Theta_B \mu \\ [0,1] \quad if & p = \Theta_B \mu \\ 1 & p < \Theta_B \mu \end{cases}$$

Sellers

Sellers

- Sellers
  - Mass = 1
- Utility
  - with car: $\Theta_S\, q + m$
  - without car: $m + p$
- Information
  - Know quality of own car
- Decision
  - Sell iff: $\Theta_S\, q \le p \;\Leftrightarrow\; q \le p/\Theta_S$

Sellers

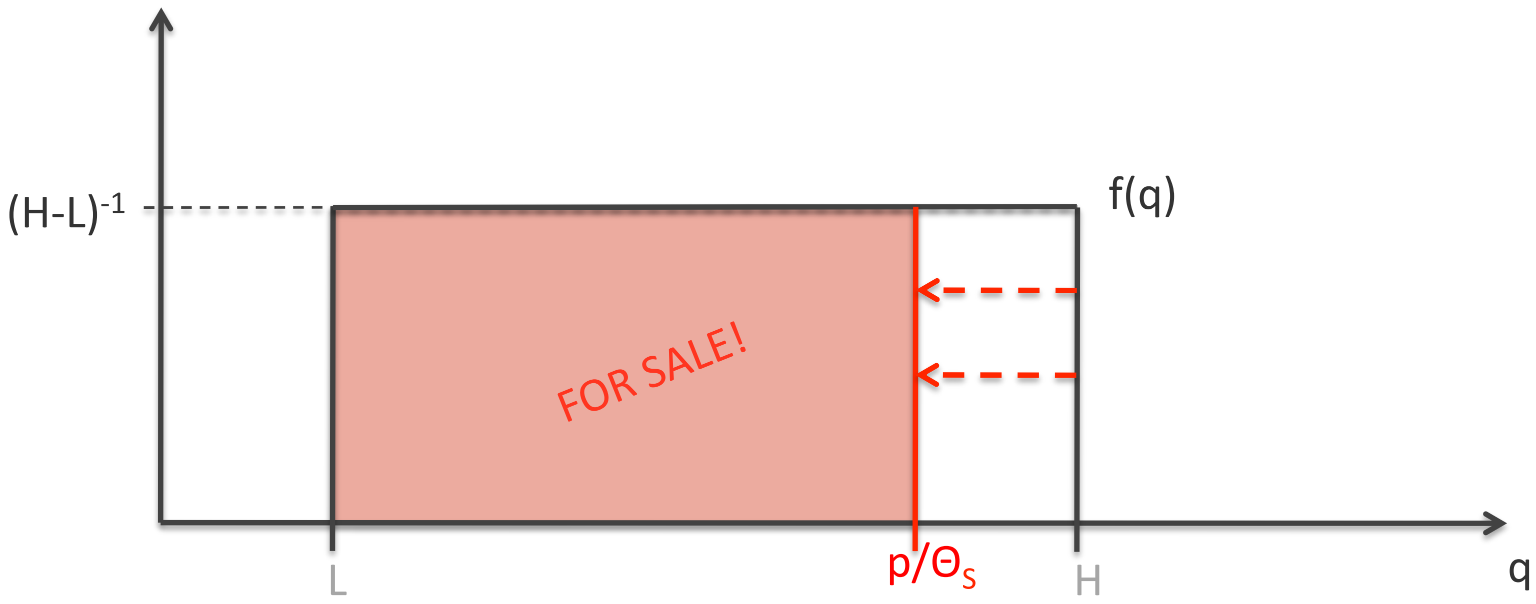
- Assume
  - $\Theta_B > \Theta_S$
  - Buyers' willingness to pay higher than sellers' willingness to accept
- Efficiency
  - All cars should be sold

Sellers

- Adverse selection

Sell iff $q \leq p/\Theta_S$

Lower price ➔ Fewer cars for sale

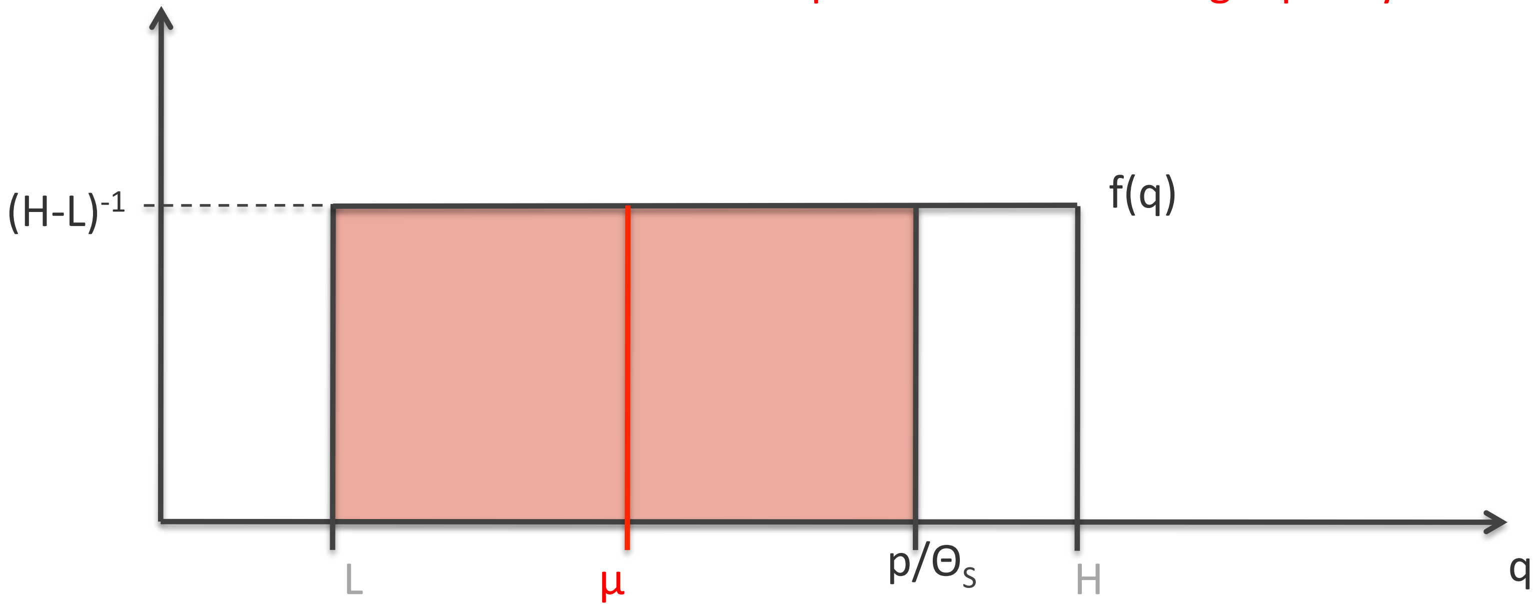


Sellers

- Adverse selection

Average quality in market
$\mu = ½ [p/\Theta_S + L]$

Lower price ➔ Lower average quality

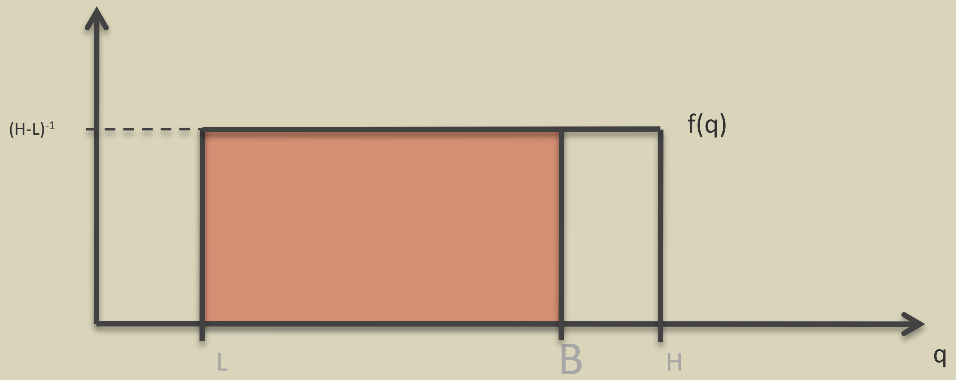


Sellers

- “Bayesian updating”
  - Expected quality of cars for sale is lower than average quality of cars in population

Market for Lemons

- Expected quality



$$\mu = E\{q | for\ sale\} = \int_L^H \frac{f(q)\cdot \Pr\{sale|q\}}{\Pr\{sale\}}\cdot q\cdot dq$$

$$= \int_L^B \frac{f(q)\cdot 1}{\Pr\{sale\}}\cdot q\cdot dq + \int_B^H \frac{f(q)\cdot 0}{\Pr\{sale\}}\cdot q\cdot dq$$

$$= \frac{1}{\Pr\{sale\}}\int_L^B f(q)\cdot q\cdot dq$$

$$\mu = \left(\frac{B-L}{H-L}\right)^{-1}\int_L^B \frac{1}{H-L}\cdot q\cdot dq = \int_L^B \frac{1}{B-L}\cdot q\cdot dq = \frac{B+L}{2}$$

Equilibrium

Equilibrium

Equilibrium

- A price such that the market clears (Demand = Supply)
- The quantity traded at this price

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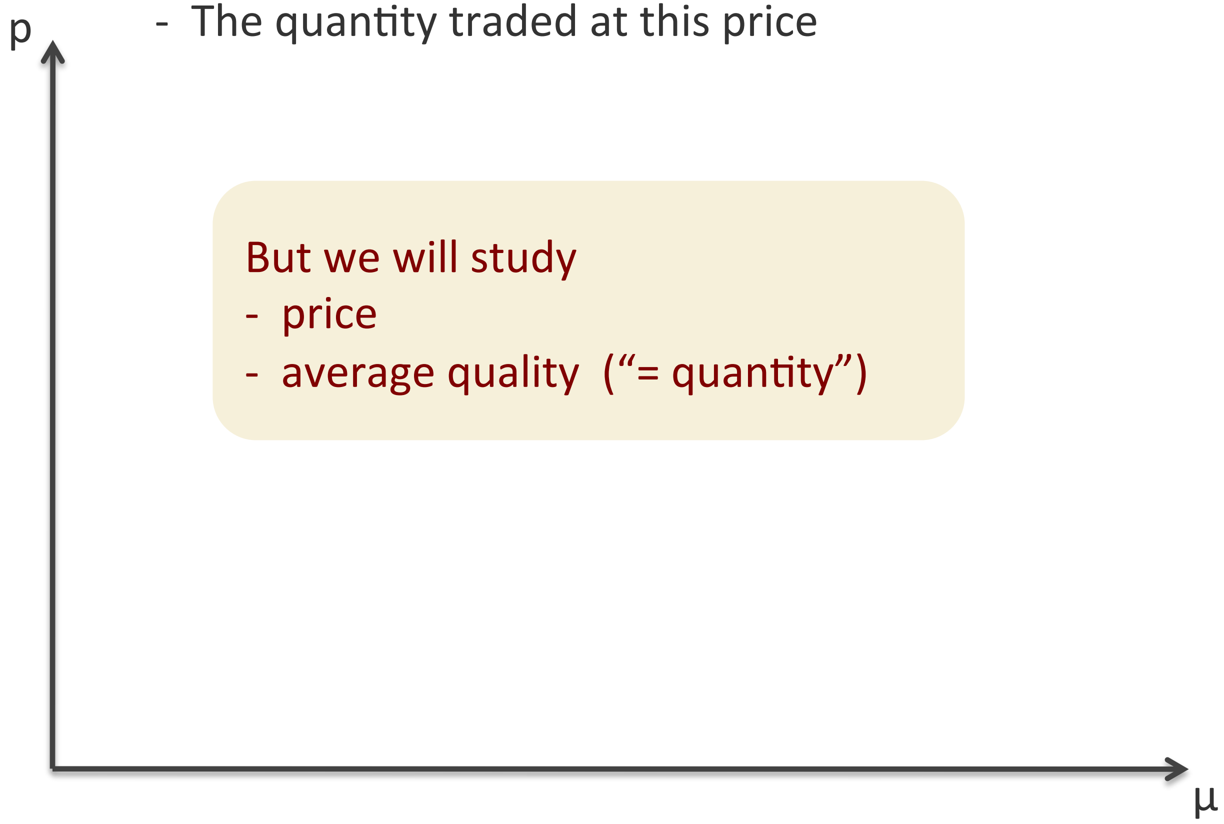
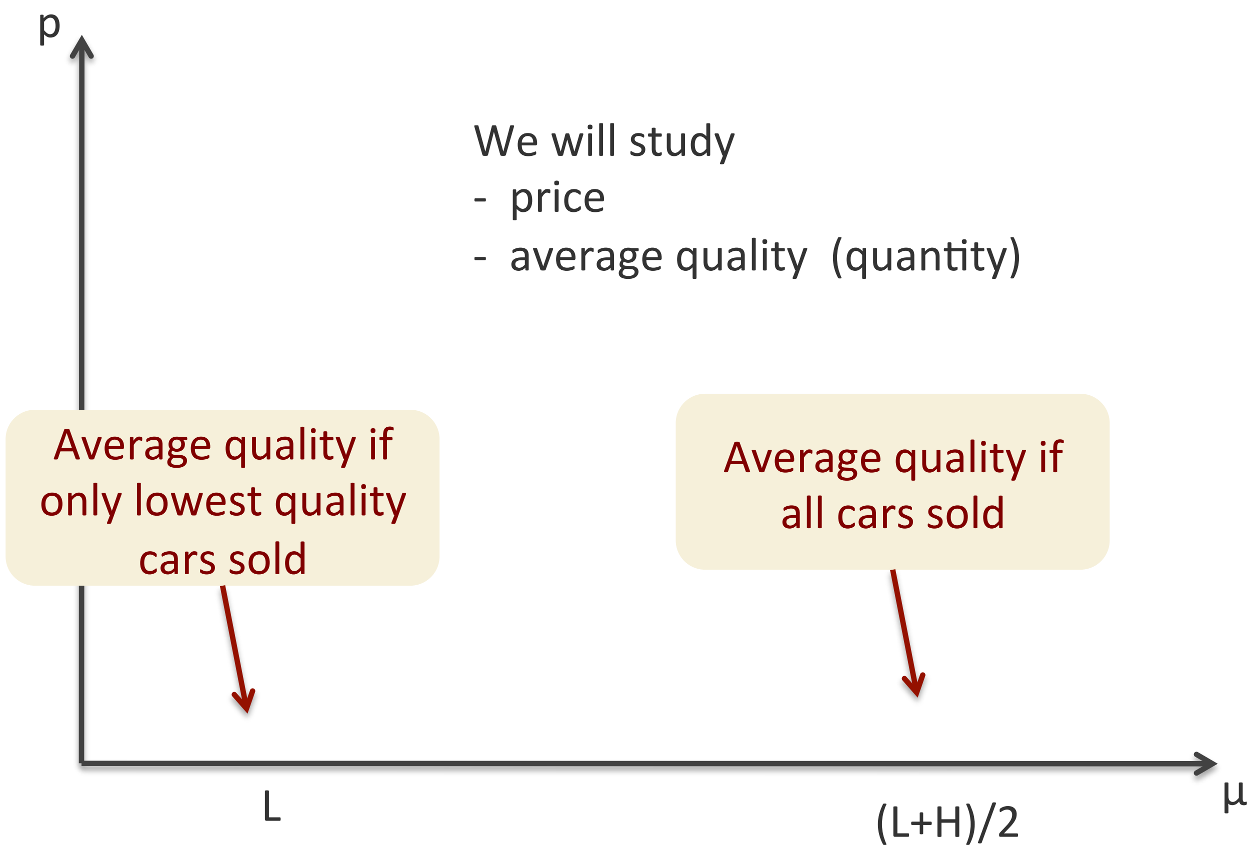
- A price such that the market clears (Demand = Supply)
- The quantity traded at this price



But we will study
- price
- average quality ("= quantity")

Equilibrium

Equilibrium
- A price such that the market clears (Demand = Supply)



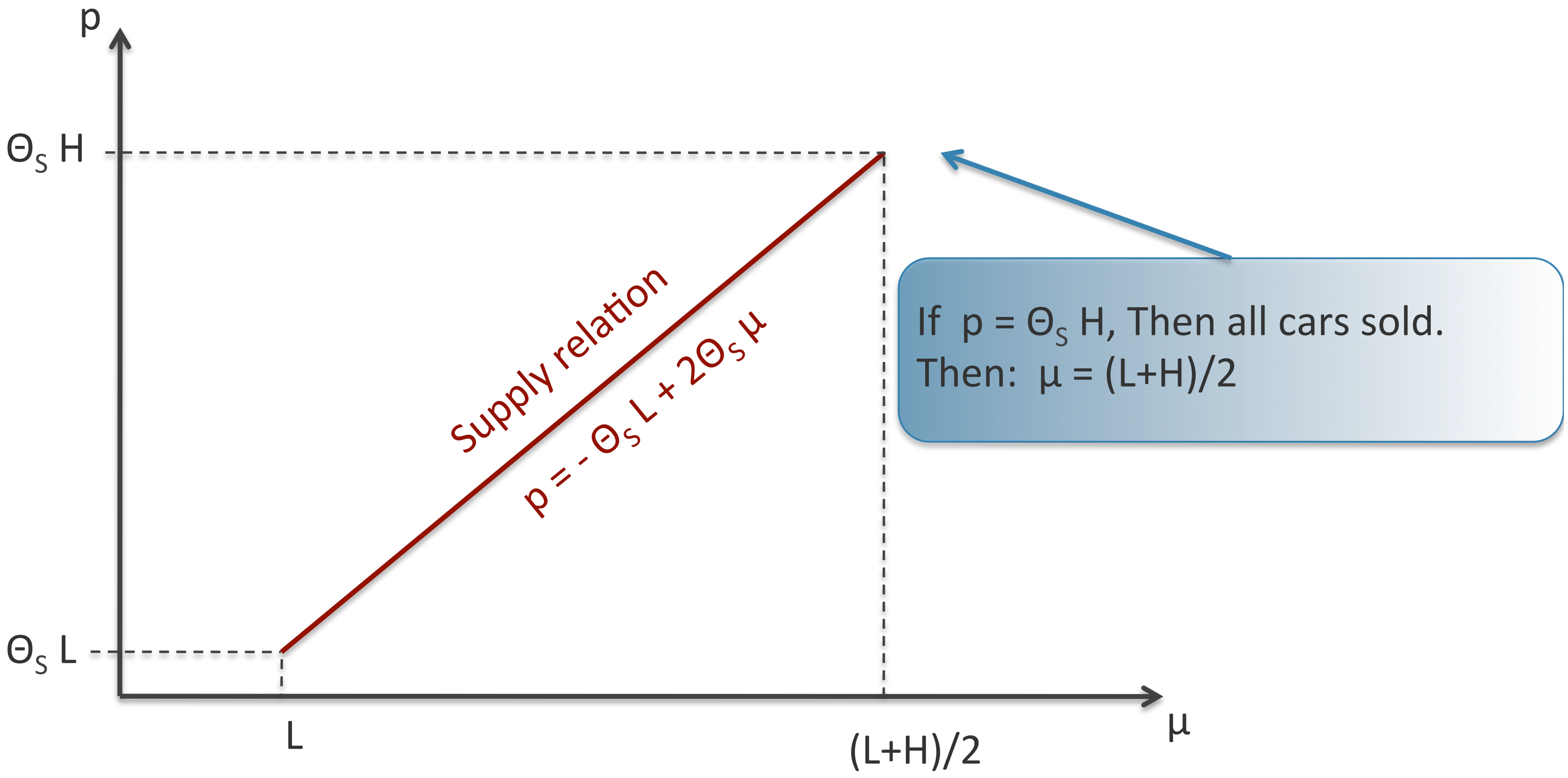
Equilibrium

- Equilibrium
  - Supply relation
    - $\mu = \frac{1}{2}\,[p/\Theta_S + L]$ ⇔ $p = -\,\Theta_S L + 2\Theta_S\,\mu$

Equilibrium

Supply relation

- Higher price => higher average quality offered



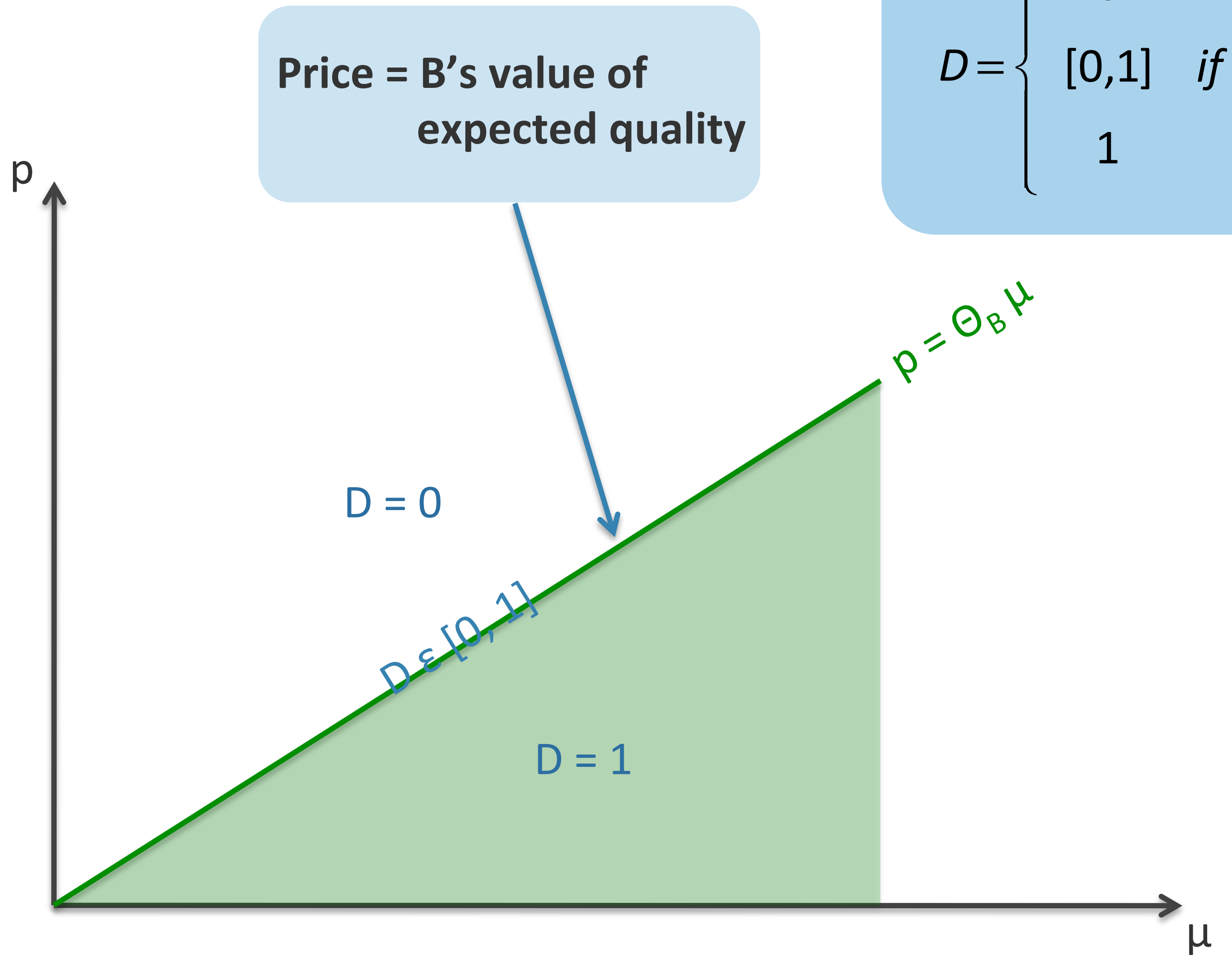
Equilibrium

- Equilibrium
  - Supply relation
    - $\mu = \frac{1}{2} [p/\Theta_S + L]$ ⇔ $p = - \Theta_S L + 2\Theta_S \mu$
  - Demand

$$D = \begin{cases} 0 & p > \Theta_B \mu \\ [0,1] \quad if & p = \Theta_B \mu \\ 1 & p < \Theta_B \mu \end{cases}$$

Equilibrium

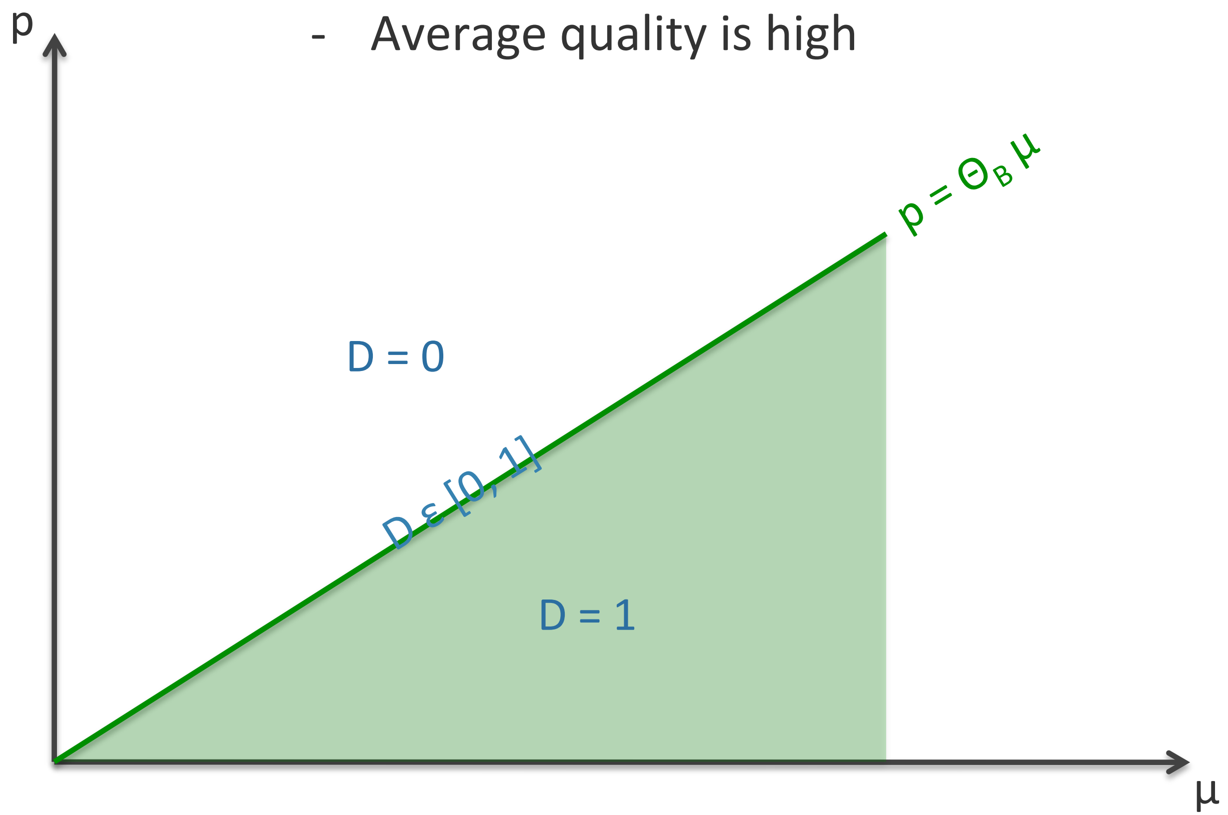
$$D = \begin{cases} 0 & p > \Theta_B \mu \\ [0,1] \quad if & p = \Theta_B \mu \\ 1 & p < \Theta_B \mu \end{cases}$$



Equilibrium

Demand relation

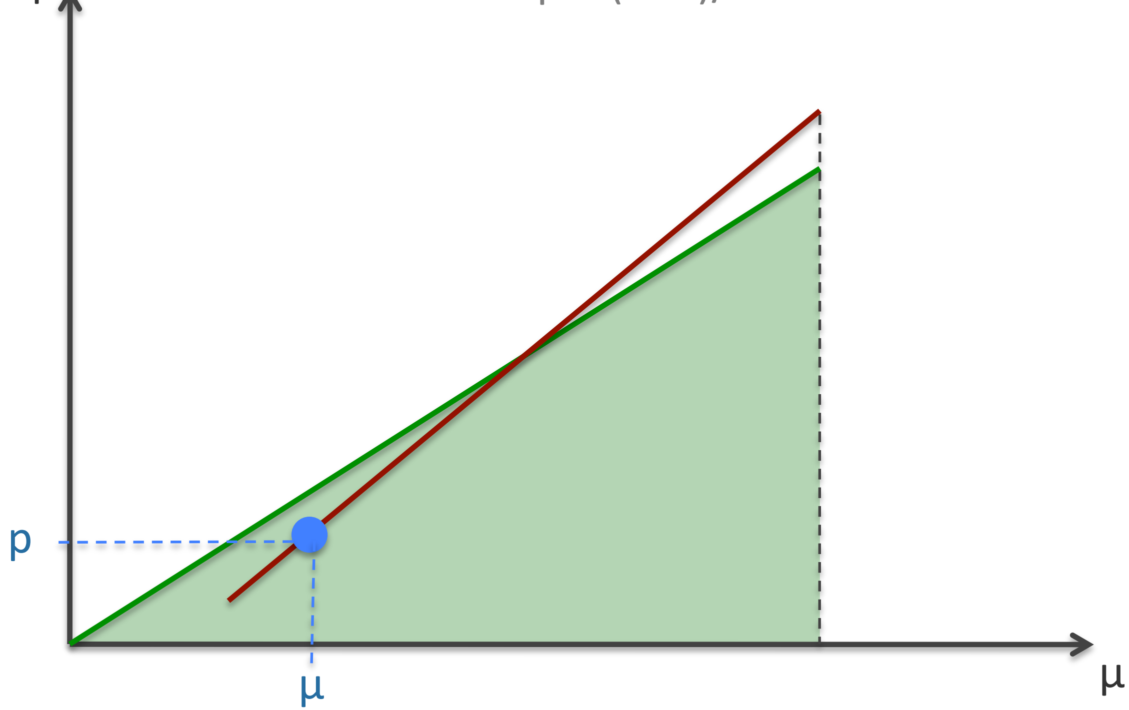
- Higher demand if
  - Price is low
  - Average quality is high



Equilibrium

Consider (p, μ) on supply-relation

- S < 1 since μ < (L+H)/2

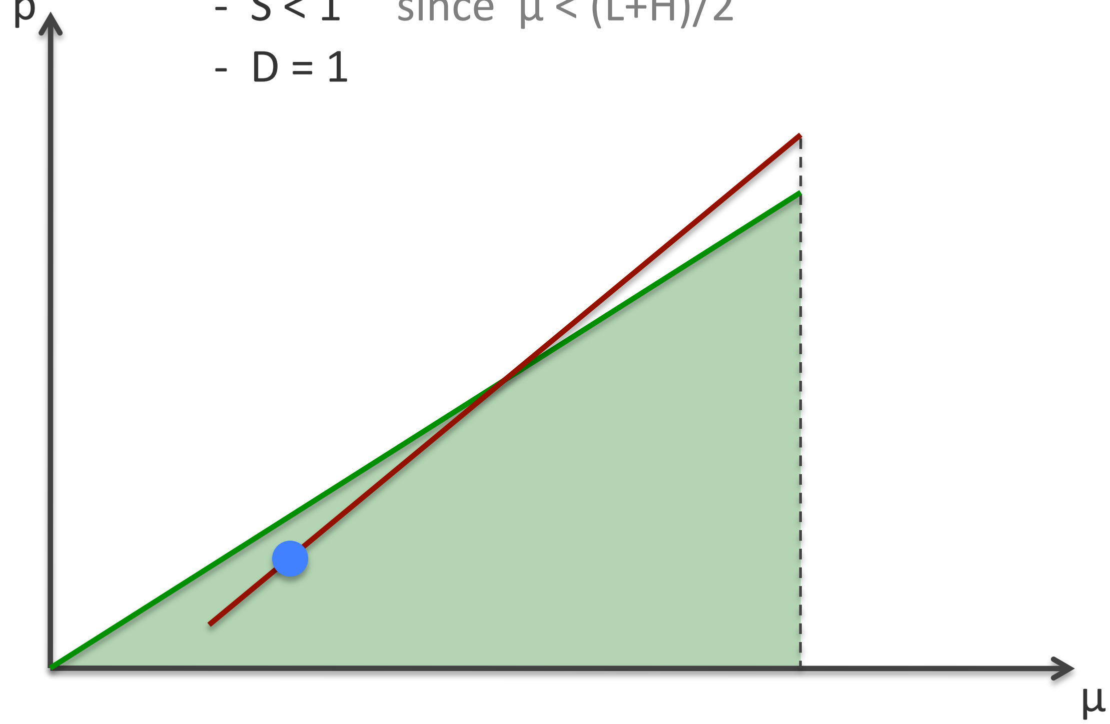


Given p, sellers will supply average quality μ

Equilibrium

Consider (p, μ) on supply-relation

- S < 1   since μ < (L+H)/2
- D = 1

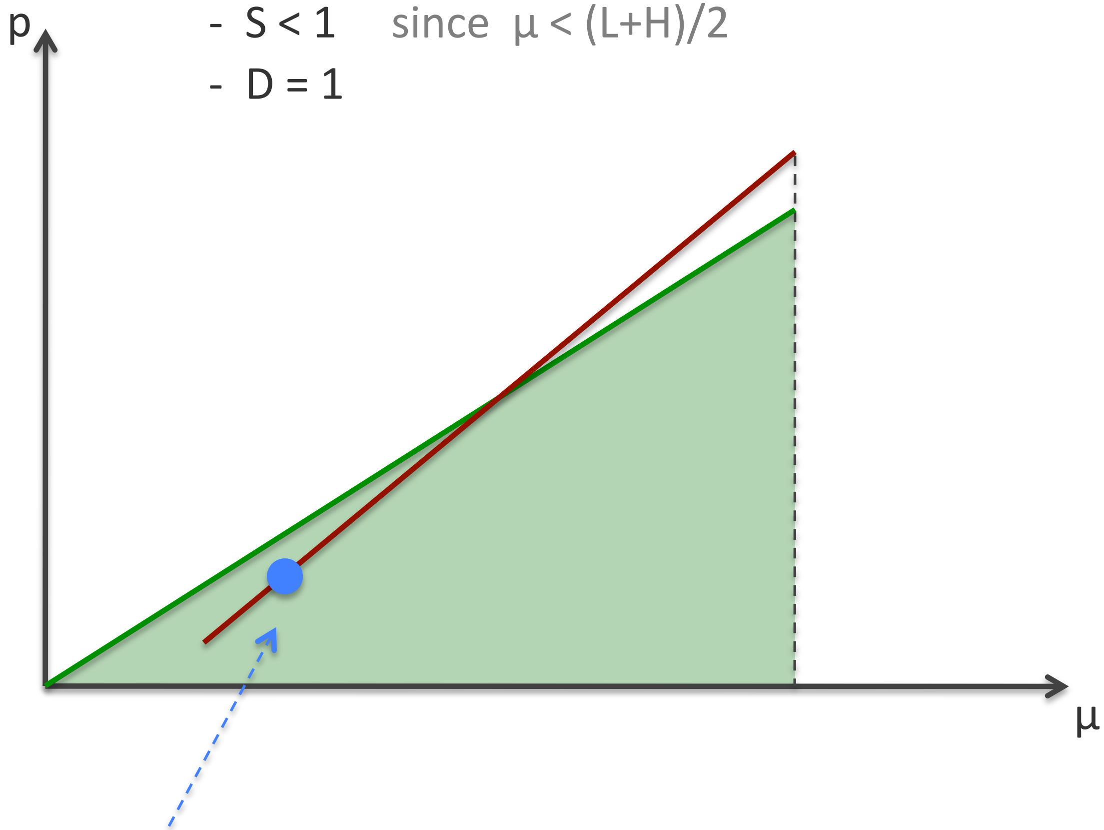


Given (p, μ) all buyers want to buy a car

Equilibrium

Consider (p, μ) on supply-relation

- $S < 1$ since $\mu < (L+H)/2$
- $D = 1$

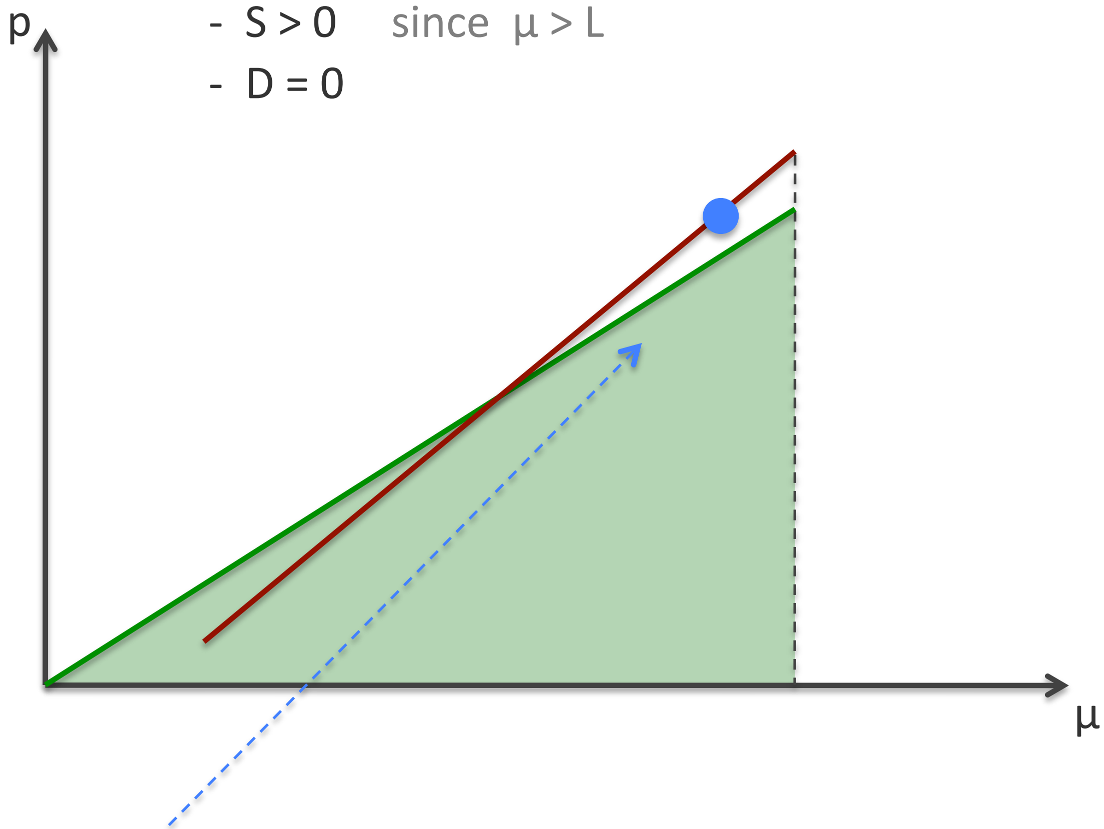


Excess demand: Price must be increased (Also quality is increased)

Equilibrium

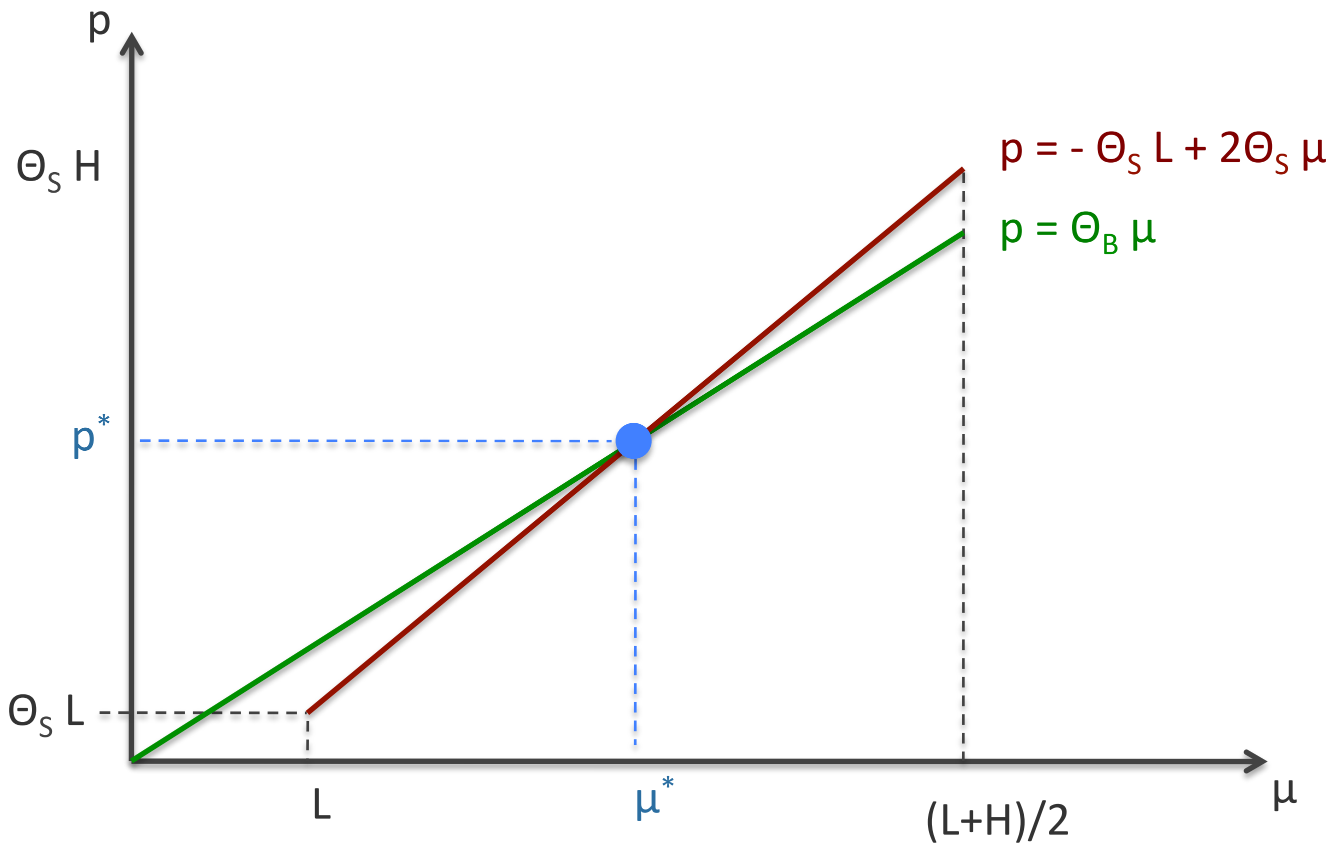
Consider (p, μ) on supply-relation

- S > 0 since μ > L
- D = 0

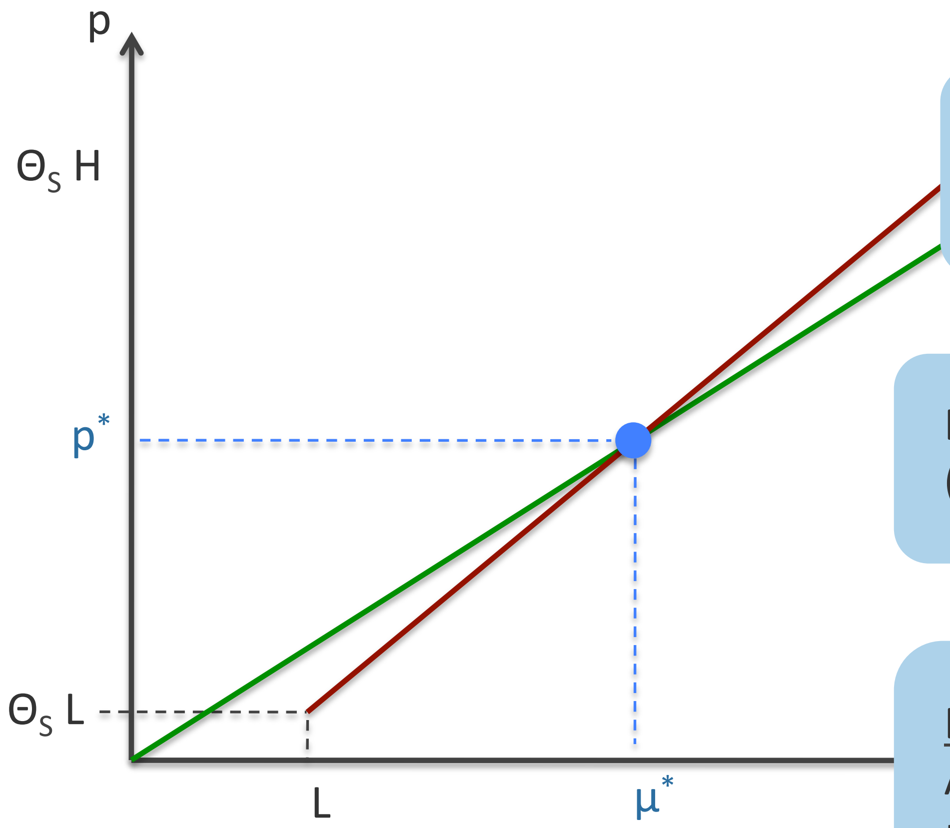


Excess supply: Price must be reduced (Also quality is reduced)

Equilibrium



Equilibrium

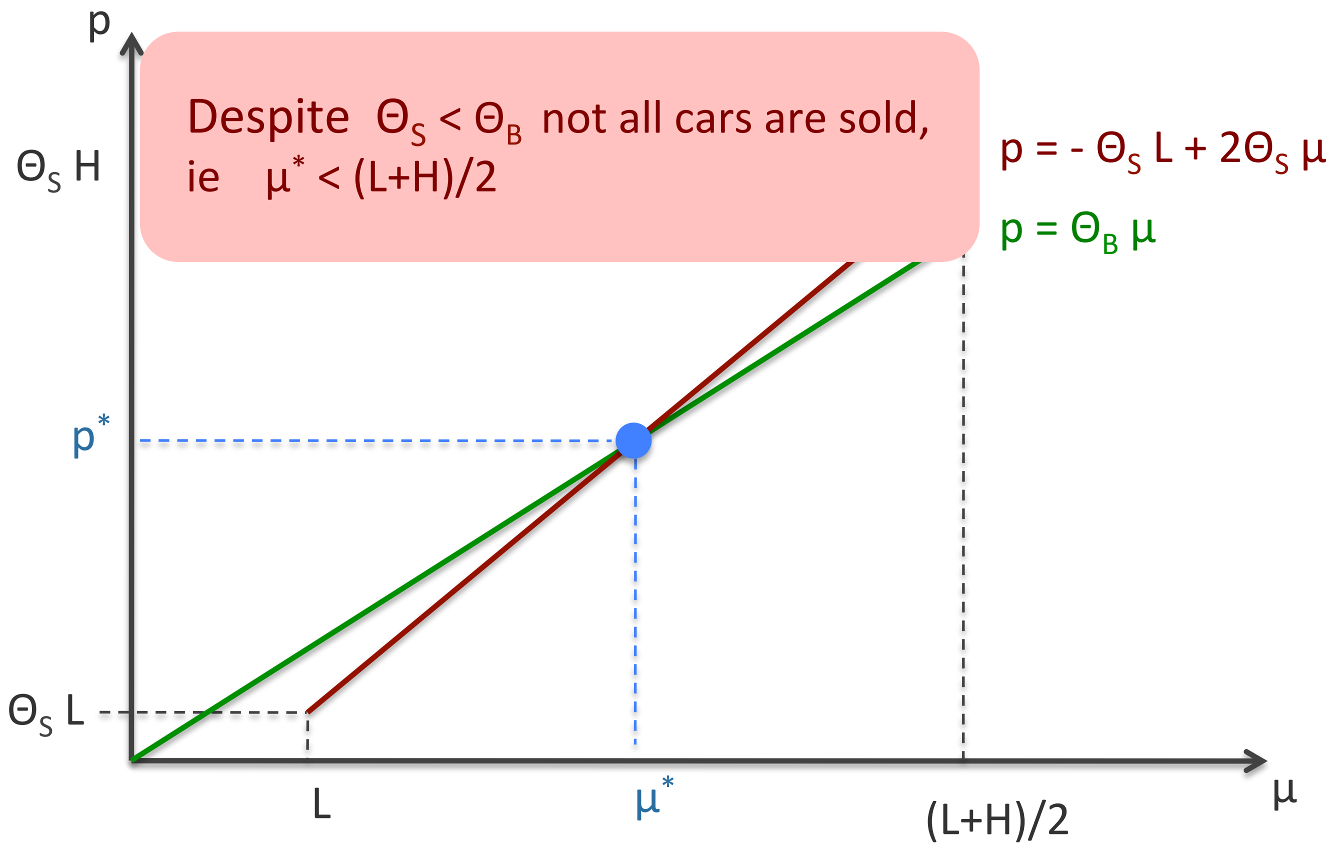


A share of sellers decide to sell
(those with low quality)

Equally many buyer decide to buy
(theory doesn't tell how they decide)

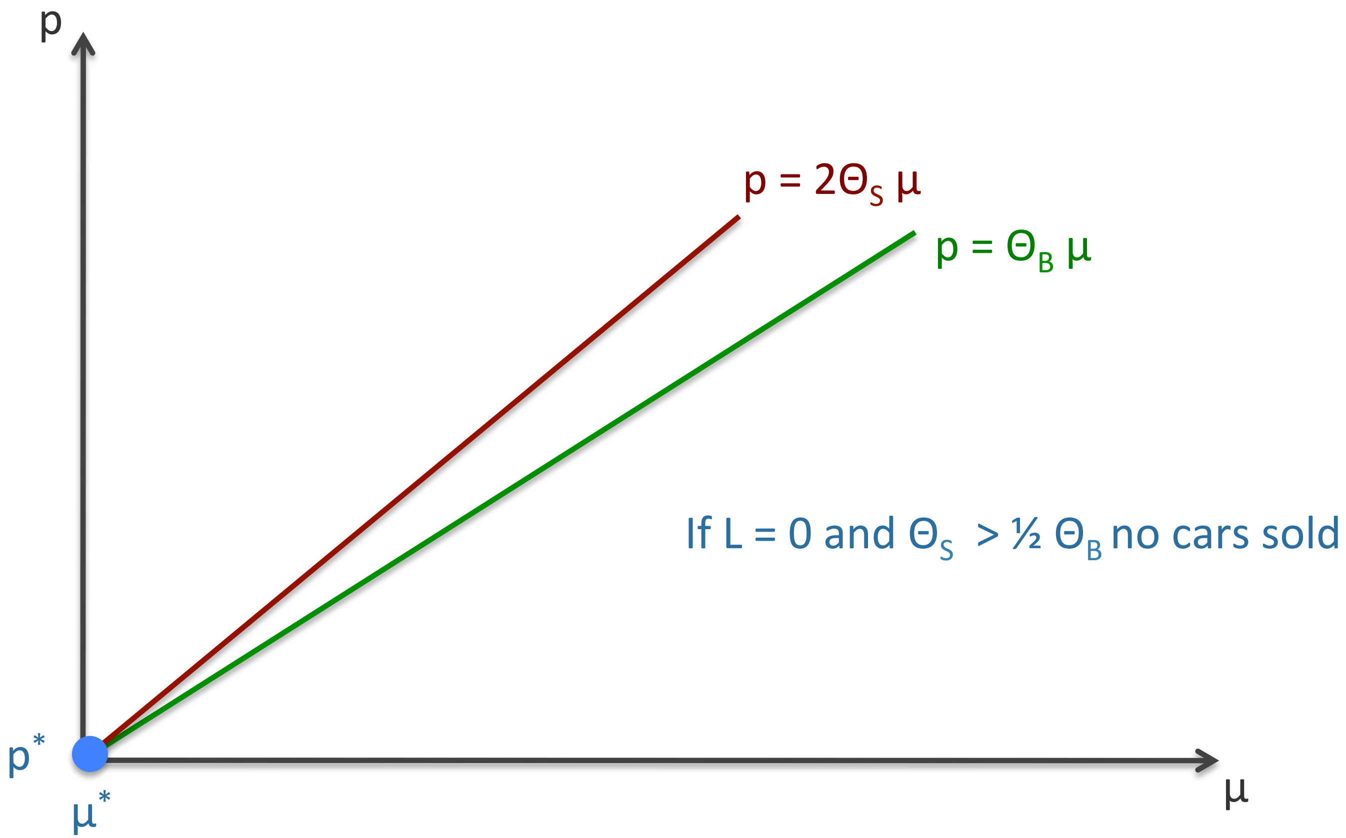
<u>Equilibrium:</u>
All buyers and sellers can realize
their plans at the same time

Equilibrium



$$\mu^* = \frac{L}{2 - \frac{\Theta_B}{\Theta_S}}$$

Equilibrium



What if all uninformed?

Incomplete but Symmetric Information

- If no one observes quality
  - Buy if $\Theta_B \mu \geq p$
  - Sell if $\Theta_S \mu \leq p$

  - If $\Theta_B \geq \Theta_S$ there exists an equilibrium where all cars are sold, at uniform price eg $p = \mu(\Theta_B + \Theta_S)/2$

- Not uncertainty, but *asymmetric* information causes adverse selection

Applications

Insurance Market

- Problem: Adverse selection spiral
  - People with high risk of becoming ill buy insurance
  - Insurance company must charge high fees
  - Then, low-risk individuals don't buy
- Solution
  - Mandatory insurance
    - E.g.: Financed with taxes in Europe
    - E.g.: Obama-care in the US

Labor Markets

- Problem
  - People with low productivity apply for new jobs
  - Employers must set low wages
  - Then, high-productivity workers stay at old jobs
- Possible solutions
  - Internal labor markets
  - Signaling and screening
    - High education to prove high productivity

Credit Market

- Problem
  - Firms with high risk of bankruptcy borrow
  - Bank must charge high interest rate
  - Then, low-risk firms don't borrow
    (their expected price is higher)
- A solution: Credit rationing
  - Banks don't increase interest rate, despite excess demand
  - Ration credits instead

Signaling & Screening

Signaling & Screening

- Market for lemons
  - Akerlof (1970)
- Solution 1: Signaling
  - Spence (1973)
- Solution 2: Screening
  - Rothchild and Stiglitz (1976)

Signaling

Signaling

- Problem
  - Employers cannot observe productivity
  - Also low-productivity workers have incentive to claim high productivity

Signaling

- Basic idea
  - High-productivity workers:
    - invest in education
  - Employers:
    - higher wage to educated
  - Low productive workers:
    - cost of education higher
    - wage premium not sufficient

Screening

Screening

- Similar to signaling
    1. Uninformed party moves first: Sets up menu of contracts to sort informed
    2. Informed self-select
- Example
    - Second degree price discrimination