Market Mechanism Game Theory

INFO 4220 – Networks II: Market Design

Today

- We talk about what defines a market
- Discuss how transactions are typically arranged
- And see a few examples in which cases it doesn’t work
- We will then talk about game theory and why it is important for market design

What is a Market?

- You have a collection of buyers that want to buy something (for example, oranges)
- And a collection of sellers that want to sell that something (for example, oranges)
- Markets are the institutions where buyers and sellers meet to agree on a price (market for oranges)
- We are going to start looking at how prices are determined in perfectly competitive markets
  - Then see what happens in less traditional markets
  - And then what happens in less common markets

Prices & Markets

- Typical transactions are based on prices:
  - Prices are the signal that agents use to evaluate tradeoffs
- When thinking in economic terms, we are always talking about tradeoffs (for example, exchanging money for a product/service)
  - I give away my money for a bag of oranges, do I value a bag of oranges more than they money I paid for it?
- In market economies, prices are determined by interactions between consumers and producers
  - These interactions happen in markets

Extent of a Market

- In markets, it is necessary to define what are the boundaries
  - What are the products?
  - Who are the customers?
  - Where is it being sold?
  - How is it being sold?
- What is TikTok's market?

TikTok's Market

- It's complicated:
  - Their revenue comes from advertising. Advertisers pay to show you ads. Ads are sold to highest bidder
  - You spend time on TikTok because you want to see entertaining videos
    - You are paying with your "labor" of watching ads
    - You are also paying with your data, which TikTok mines while you use the app, and that TikTok use to increase the value of showing ads to you
  - You could also post videos on TikTok and get paid for your content. Most people post videos and don't get paid

Extent of a Market

- Critical definition in antitrust law: What is the market? Is the firm harming consumers in the market?
- Current US antitrust law is based on prices and consumer harm
- How do you say Google is a monopoly that harms consumers if their products and services are free
- Recent antitrust lawsuit against Google:
  - Is based on the advertising business
  - Claims Google abuses its power and as a result:
    - Websites that rely on Google ads revenue earn less than they should
    - Advertisers end up paying more than they would, and those cost are eventually passed down to consumers

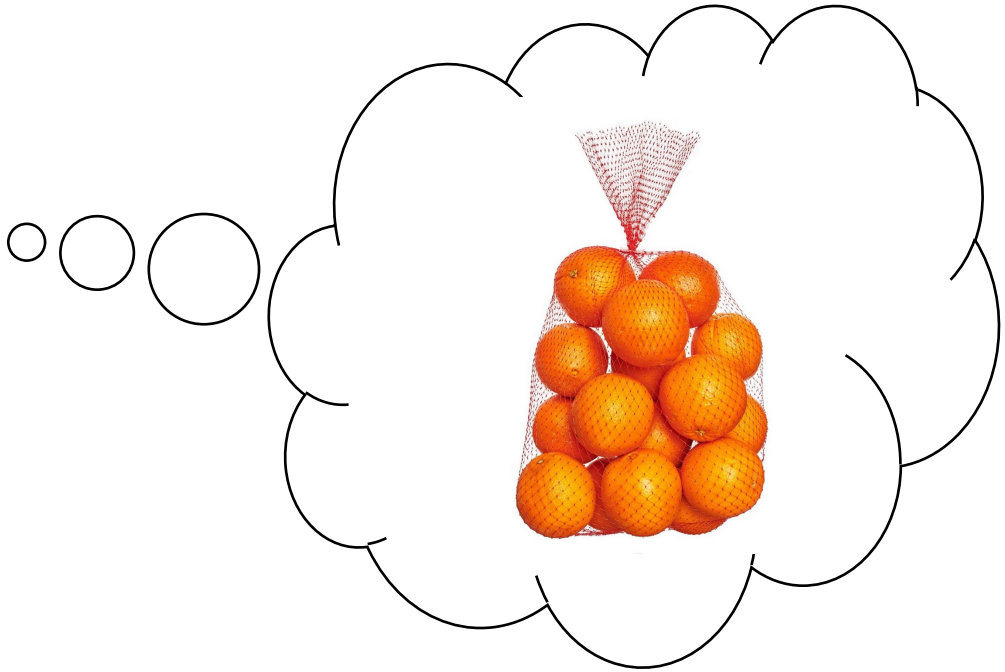
Why the DOJ says Google Abuses its Power

- This lawsuit is about display advertising, not search ads (or ads you would see in YouTube, Gmail…)
- Publishers (think websites) use Google's ad-tech stack to sell advertising space
- Google controls the supply side (publishers), the advertising exchange (where ad buyers and ad sellers buy/sell ads), and the demand side (advertisers)
- There is competition in all these segments, but Google offers much worst conditions to publishers that don't use their supply side platform, and advertisers that don't use their demand side platform

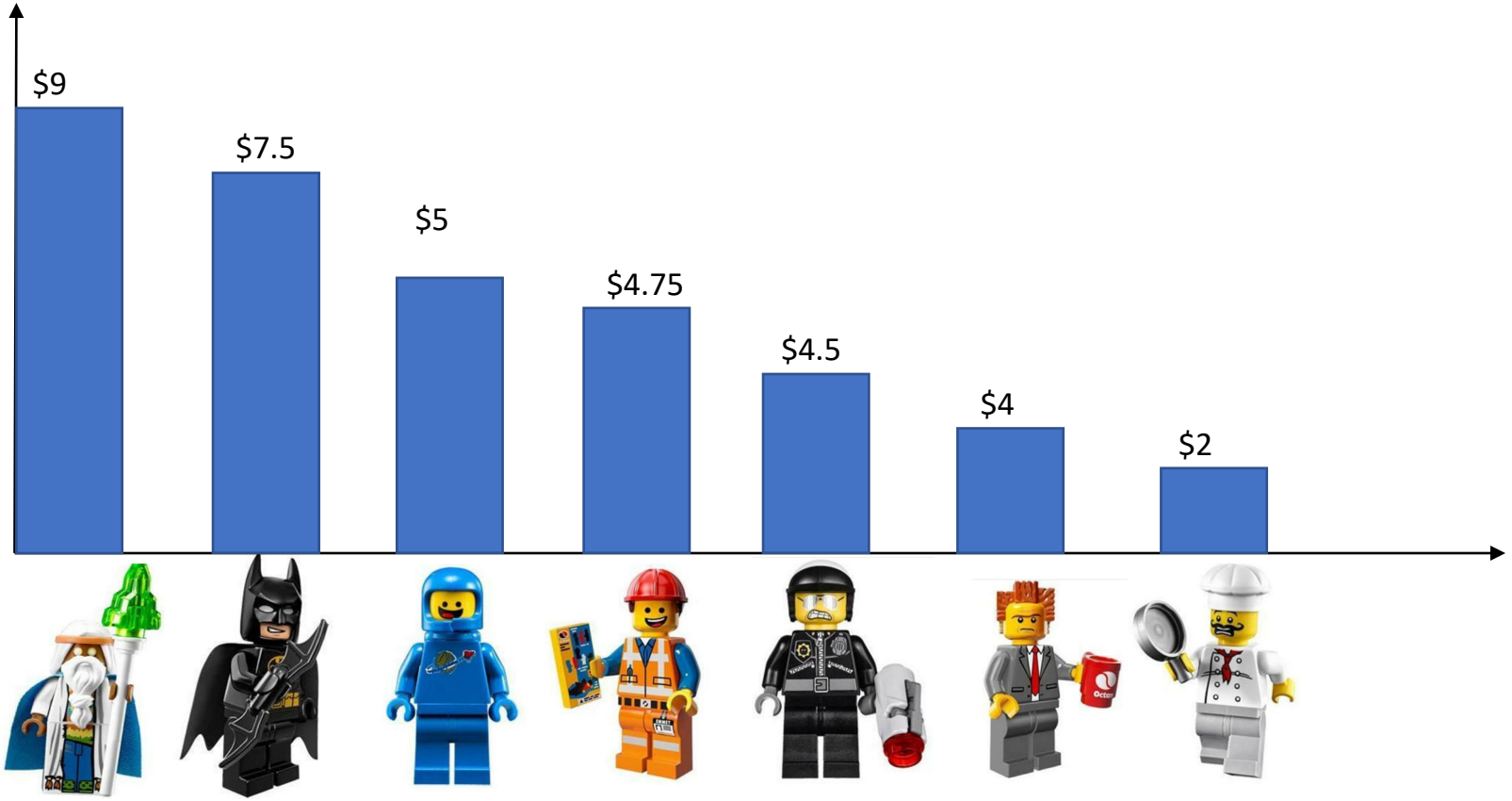
Supply and Demand

- A thick market is a market where there are many buyers and sellers
- Without intervention, supply and demand will come to an equilibrium that determines prices and quantities to be traded
- The model of supply and demand is the workhorse of economics

The Demand Curve



The Demand Curve

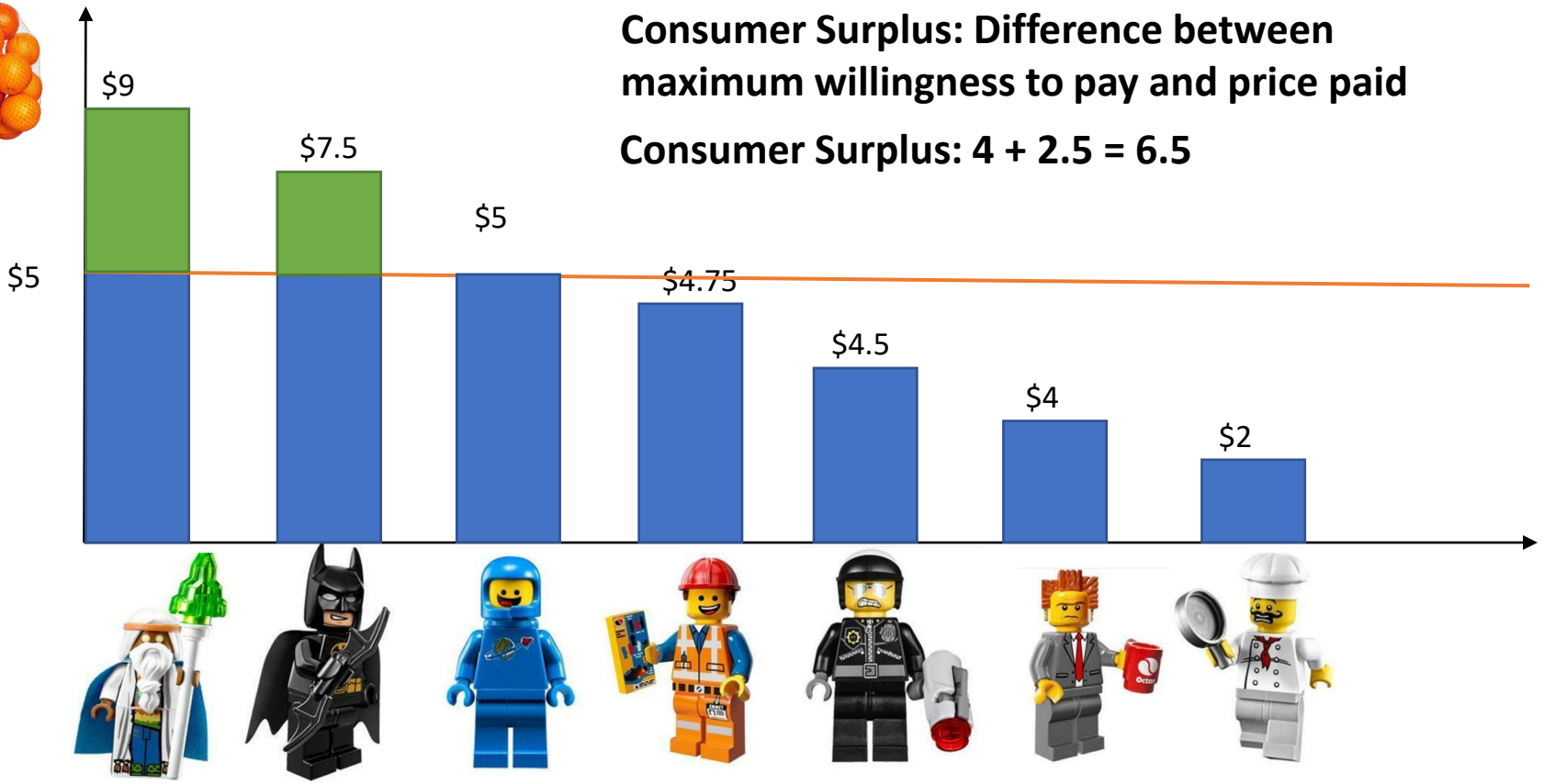


Consumer Surplus

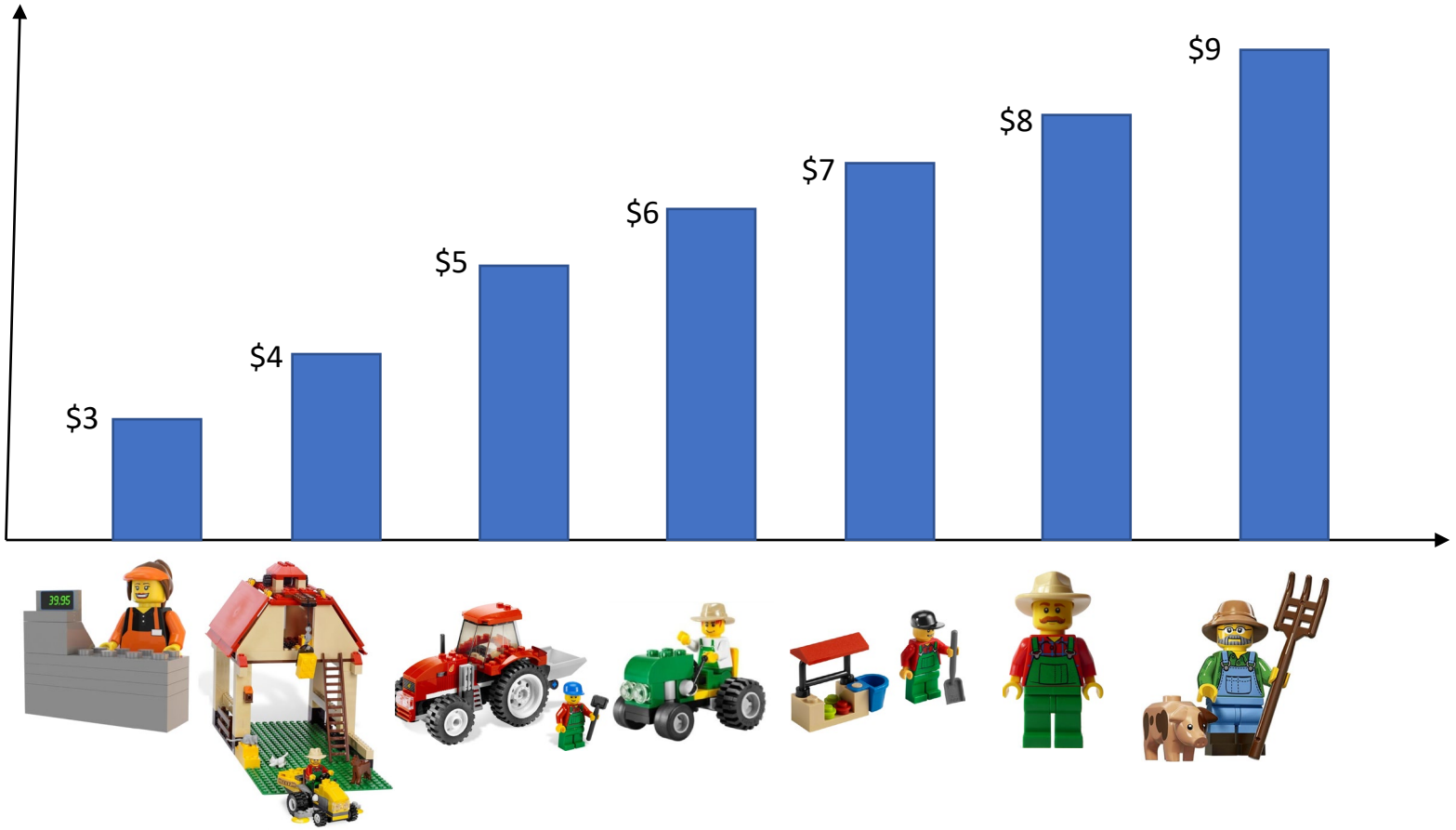
Let's just assume that a bag of oranges costs $5

Consumer Surplus: Difference between maximum willingness to pay and price paid

Consumer Surplus: 4 + 2.5 = 6.5



The Supply Curve



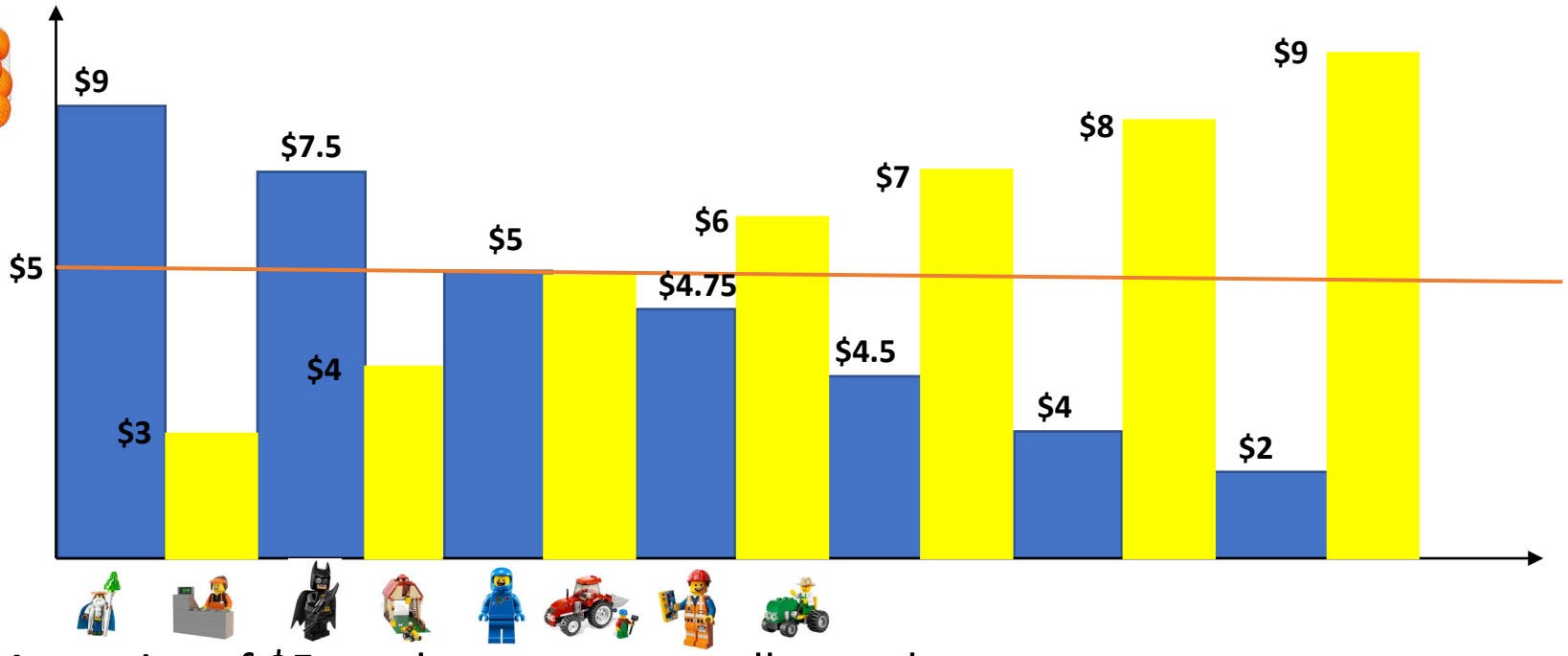
Producer Surplus

Let's just assume that a bag of oranges costs $5

Producer Surplus: Difference between minimum willingness to accept and price goods were sold

Producer Surplus: 2 + 1 = 3

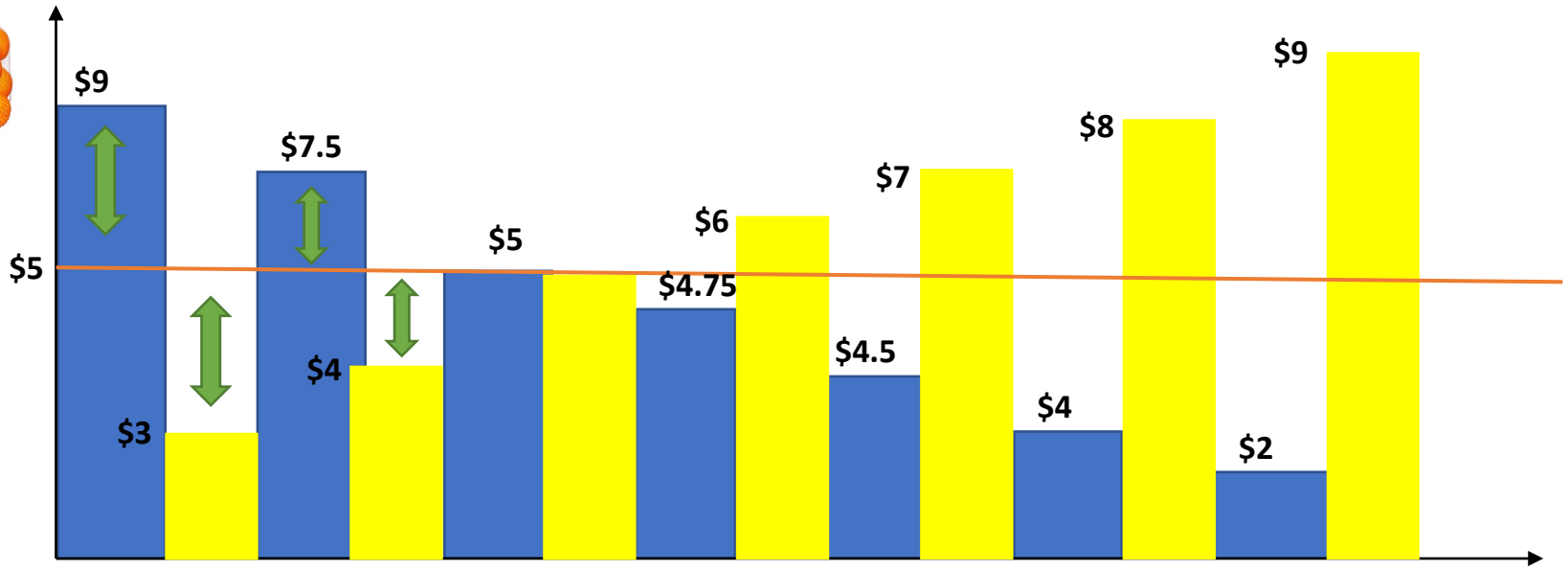
How are Prices Set



At a price of $5 you have as many sellers as buyers:

- If price was higher, there would be more people willing to sell than willing to buy
- If price was lower, there would be more people willing to buy than willing sell

Gains from Trade



Because of the market, buyers and sellers could engage in transactions that left them better off:

- Buyers that bought were willing to pay more for the oranges (at least 2 of them). They change $5 for something they value at more than $5
- Sellers were willing to sell the oranges for less than $5 and received $5
- Any other price than the market equilibrium would be inefficient

Economic Welfare and Market Efficiency

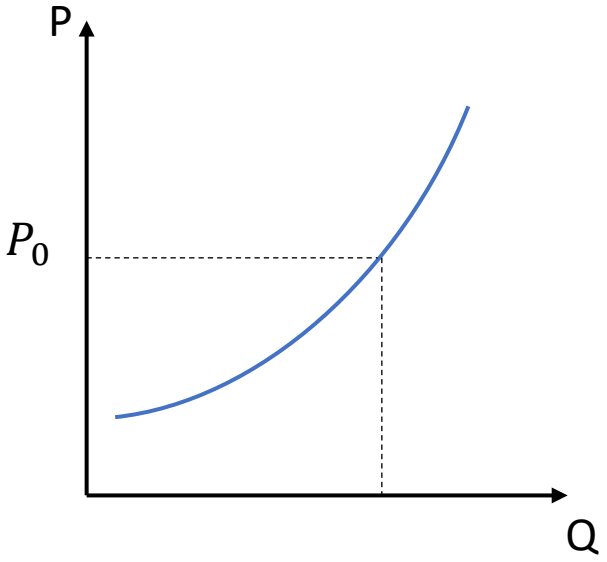
- The consumer surplus and the producer surplus are measure of economic welfare
  - Gains from trade that happen thanks to markets
- We use them to evaluate how well/bad a market works
- We will see that in other markets (for example when no money changes hands) we will need other ways of measuring market efficiency

Example PollEV

There are some students that want to sell their iClickers they no longer need, and some others that want to buy a used iClicker. Table below shows their WTP/WTA to sell/buy. What price would be efficient? (if this was a perfectly competitive market, what would be the equilibrium price)

Buyer	WTP	Seller	WTA
Alice	20	Gabriel	5
Bob	10	Henry	10
Carol	15	Isabelle	15
David	25	Jacob	18
Eleanor	30	Karen	50
Freddy	25	Lucas	30

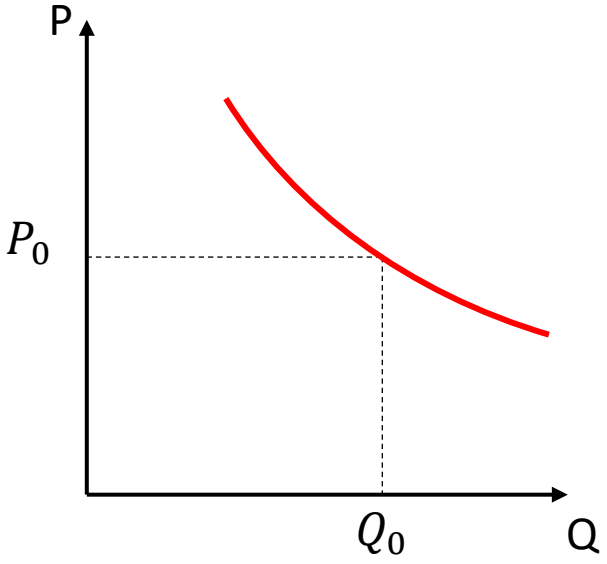
Supply Curve



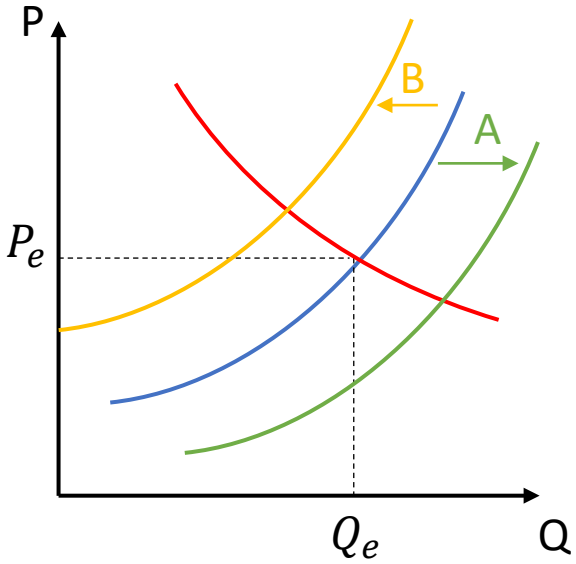
- Represents the quantity that producers are willing to sell at a given price
- Vertical axis is price
- Horizontal axis is quantity
- Supply function is defined as: $Q_S = Q_S(P)$
- Could also depend on other factors, for example costs of Labor and Capital
- Always has positive slope: $Q_S' > 0$
- Generally convex: $Q_S'' > 0$ (but can be anything)

Demand Curve

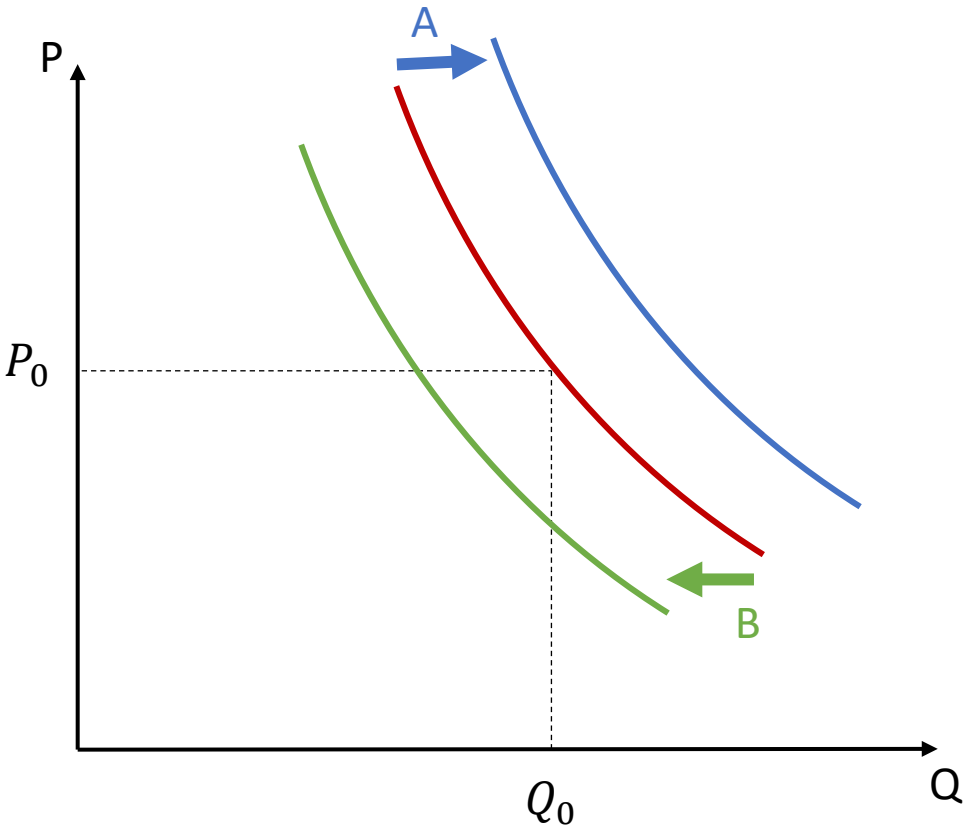
- How much are consumers willing to buy at different price levels
- Function: $Q_D = Q_D(P)$
- It could depend on other factors as well, for example on income
- Always slope downwards: $Q_D' < 0$
- Usually concave: $Q_D'' < 0$ (but can be anything)



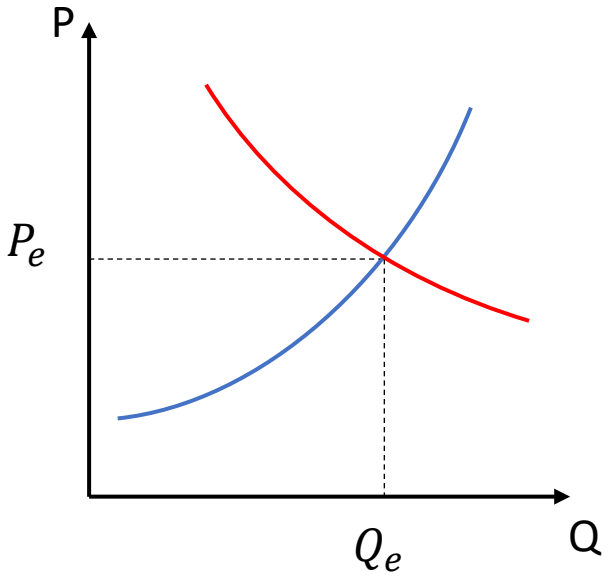
Supply Curve: What Happens if Cost of Raw Materials go Down?



Demand Curve: What Happens if Income Increases? A or B?

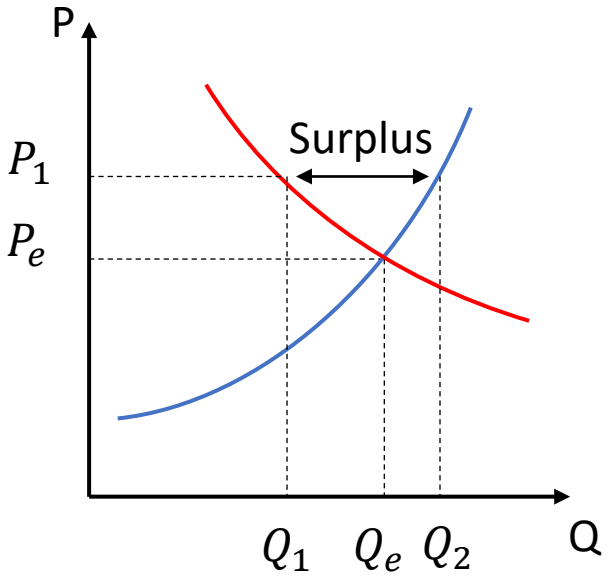


The Market Mechanism



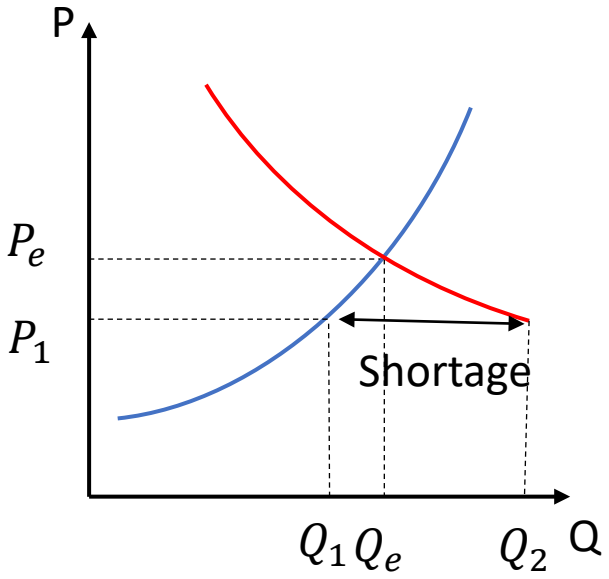
- Market Mechanism: Tendency in a market for the price to adjust until the market clears
  - No one wants to buy an extra unit at the equilibrium price
  - No one wants to sell an extra unit at the equilibrium price

What happens if $P_1 > P_e$



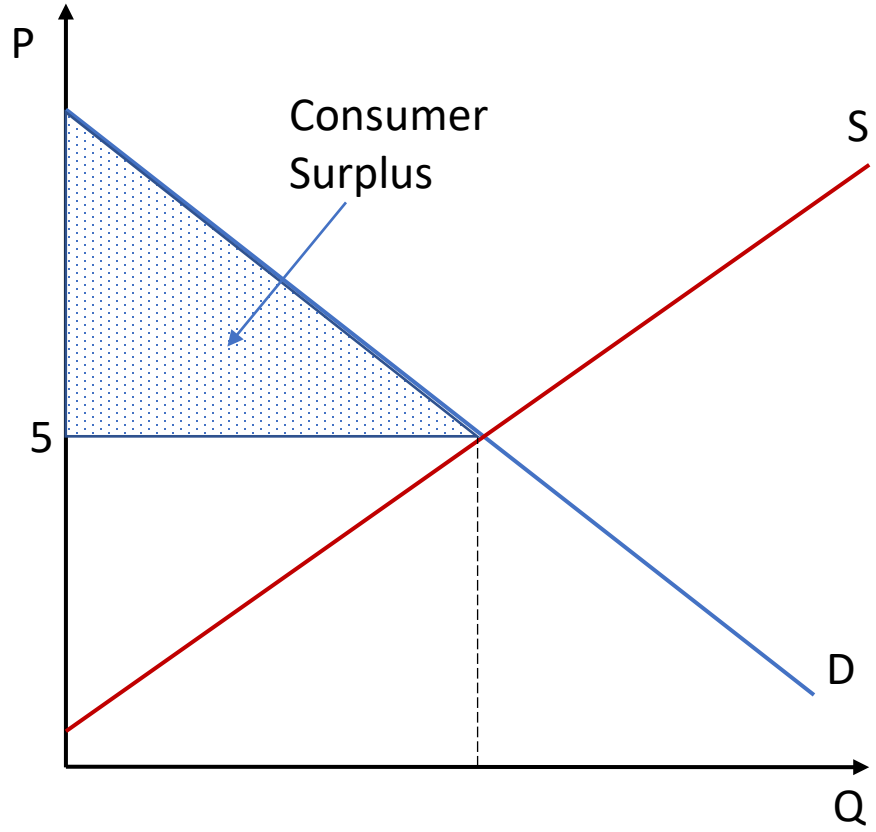
- Surplus: At price P_1, sellers want to sell Q_2 units, but buyers only want to buy Q_1
- If the price in the market was P_1
  - Producers will overproduce and units would go unsold
  - Price would be adjusted downwards

What happens if $P_1 < P_e$



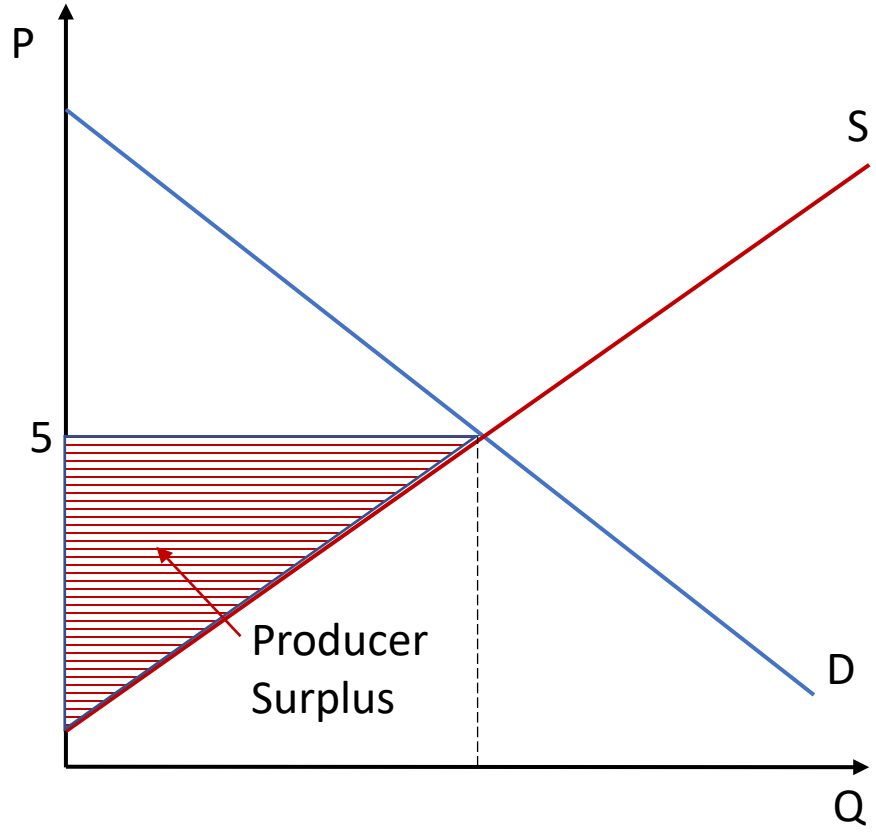
- Shortage: At price P_1, buyers want to buy Q_2 units, but sellers only are willing to sell Q_1
- If the price in the market was P_1
  - Producers will only produce Q_1
  - Product would run out and prices would be adjusted up

Consumer Surplus



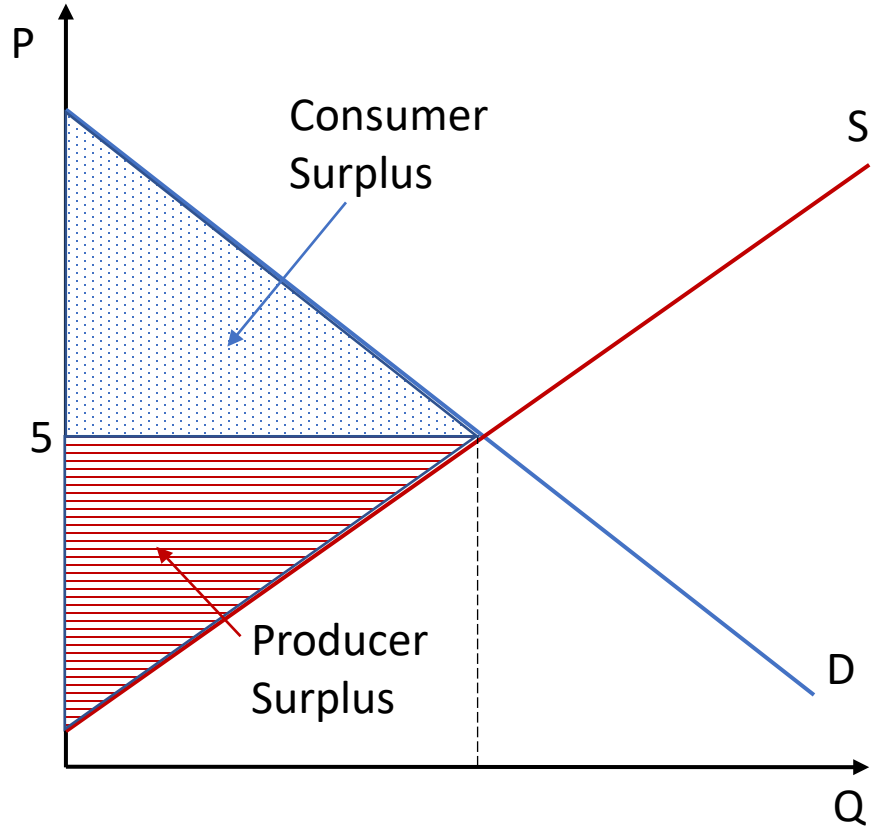
Consumer Surplus is the area between the demand curve and the price

Producer Surplus



Producer Surplus is the area between the supply curve and the price

Producer Surplus

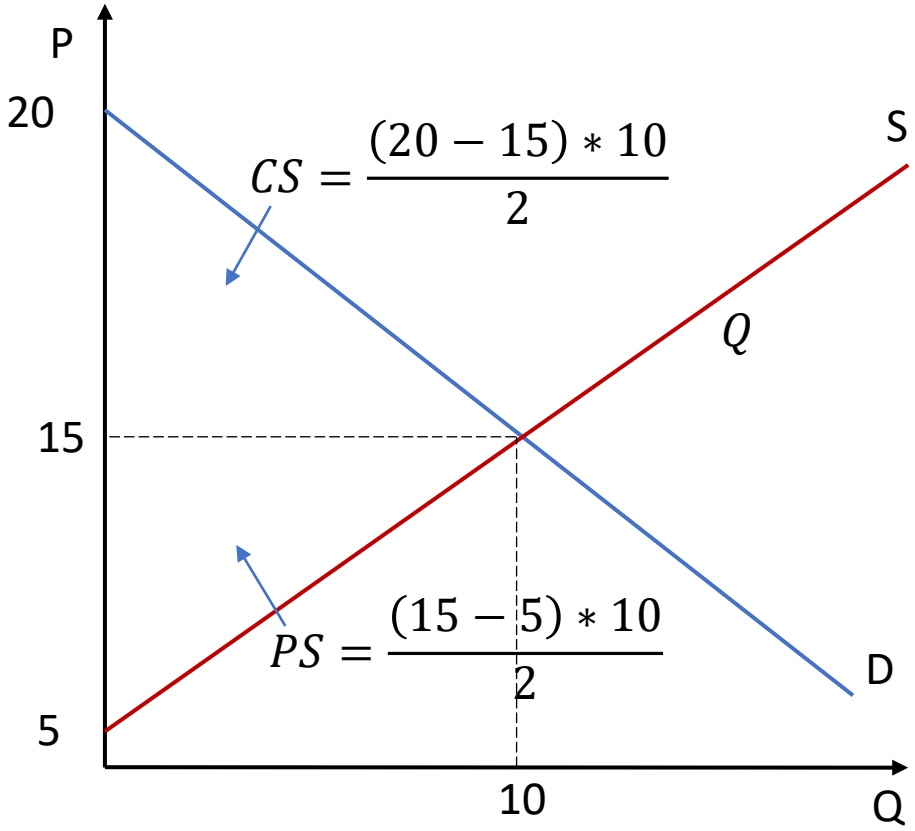


Example

The demand for "designer" face masks during the pandemic is represented by the curve $Q_D = 40 - 2P$. Mask producers are willing to sell masks according to the supply curve $Q_S = -5 + P$

a) Find the equilibrium price and quantities
b) Find the consumer and producer surplus
c) The government has decided that face masks are a necessity during the pandemic and imposed a maximum price of 10 per masks. What will happen to the equilibrium and economic welfare

Producer/Consumer Surplus



$Q_S(P) = -5 + P \Rightarrow P = 5 + Q_S$

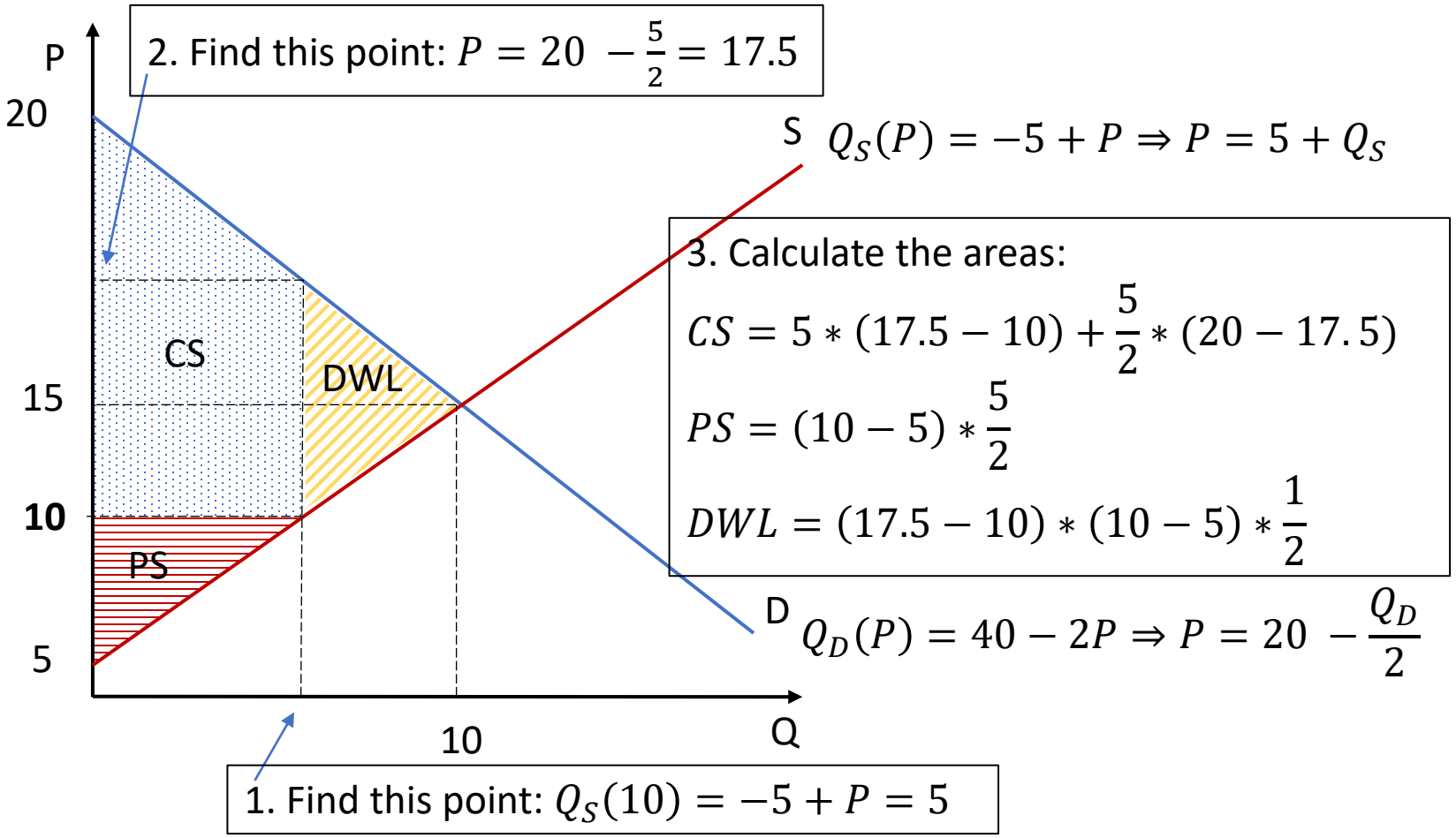
$Q_D(P) = 40 - 2P \Rightarrow P = 20 - \frac{Q_D}{2}$

1. Find equilibrium price, and equilibrium quantity: $Q_S = Q_D$

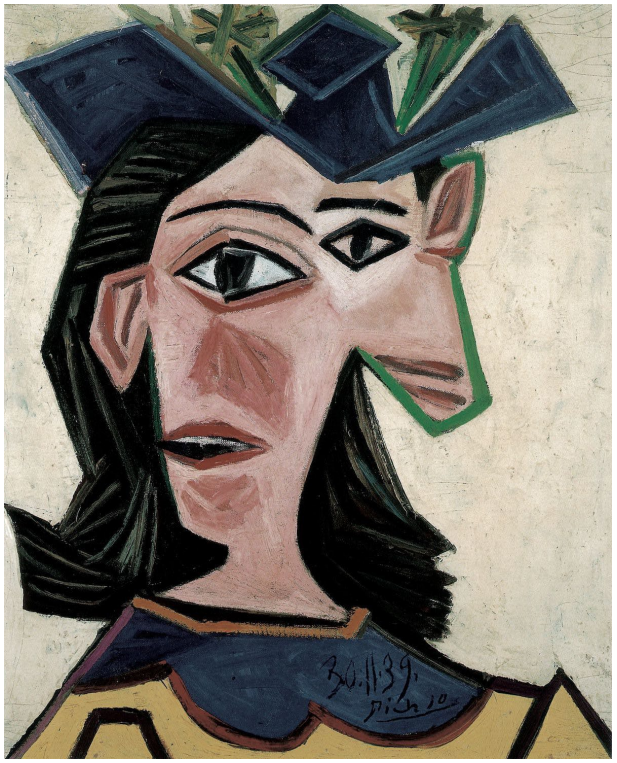
$-5 + P = 40 - 2P \Rightarrow P = 15,\ Q_S(15) = Q_D(15) = 10$

2. Find where demand and supply curve intersect vertical axis (Set Q=0 above)
3. Calculate areas corresponding to CS and PS

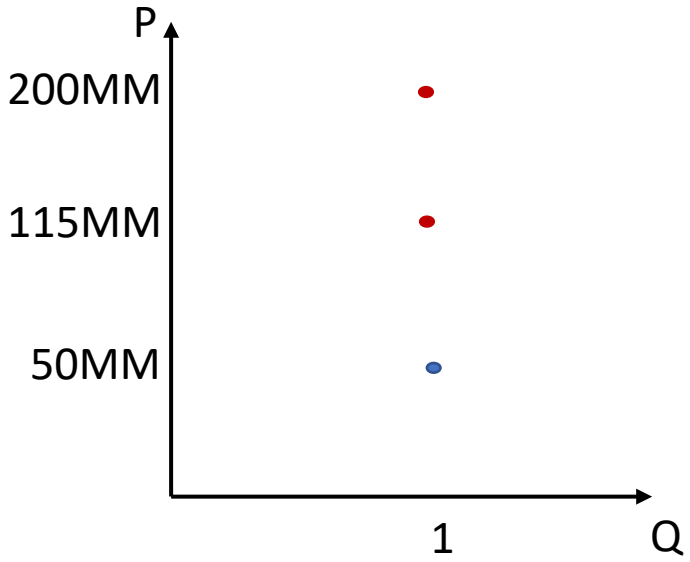
Price Ceiling



Special Case 1

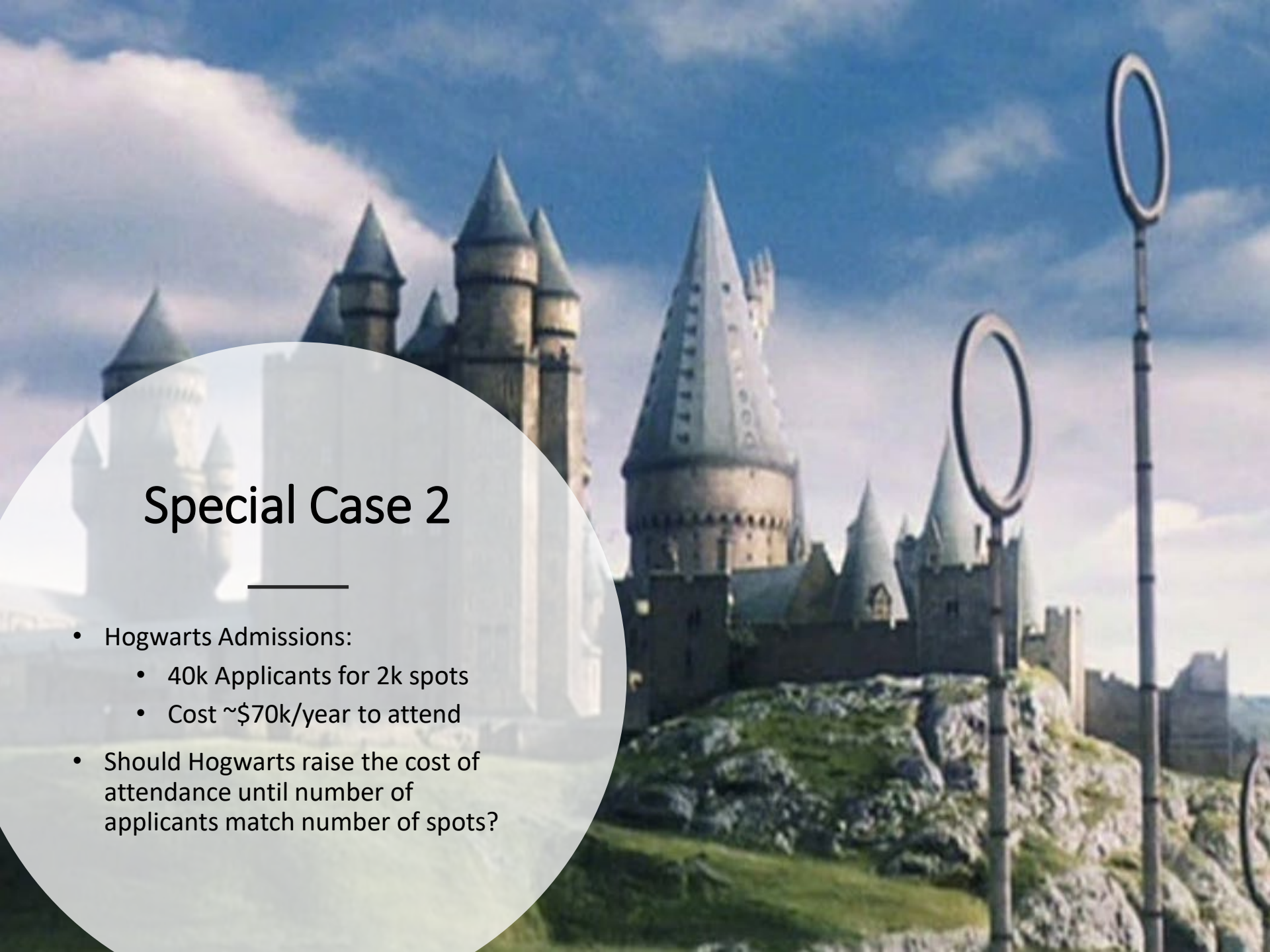


- There is one Picasso painting for sale
- Seller wants to get at least $50MM
- Buyer 1 wants to pay at most $115MM and Buyer 2 at most $200MM



All the information is private. Nobody knows others willingness to accept and willingness to pay. How do we set the price?

Image: Pablo Picasso, *Buste de femme au chapeau (Dora)*, 1939. Fondation Beyeler, Riehen/Basel, Sammlung Beyeler.



Special Case 2

- Hogwarts Admissions:
  - 40k Applicants for 2k spots
  - Cost ~$70k/year to attend
- Should Hogwarts raise the cost of attendance until number of applicants match number of spots?

Market Mechanism Summary

- Supply Curve: How much sellers are willing to sell at a given price
- Demand Curve: How much buyers are willing to buy at a given price
- Market: Institutions where buyers and sellers agree on a price
- Market Mechanism: Tendency in the market to adjust prices until the market clears (equilibrium)
- Consumer Surplus: Difference between what buyers are willing to pay and how much they pay
- Producer Surplus: Difference between how much buyers are paid, and the minimum they were willing to accept

Let’s play a game

- Next week I will release problem set 1
- In this game, I will give you the option to collude or to defect:
  - If everyone here today “colludes”, everyone will get a 10 points bonus in PS1
  - If everyone but one person “colludes”, the person that “defects” gets a 50 points bonus, and the rest gets 0
  - If more than one person defects, no one gets any bonus

What is Game Theory

- Is a set of tools to analyze strategic decision making for a group of actors and predict outcomes
- Strategic decision making refers to decision where the actions taken by one actor influences the actions and outcomes of other actors
- It has been used in many settings, including economics, military studies, political science, etc.
- We will use it because in markets and network industries the actions and outcomes of different players are influenced by the network

Types of Games

- There are two main times of games:
  - Normal Form: All players choose their actions simultaneously
  - Extensive Form: Players choose their actions sequentially
- We can also distinguish by types of actions:
  - Pure strategy: Players use a single strategy from the set of available strategies
  - Mixed strategies: Players assign a probability to playing each strategy (for example they toss a coin to choose what to do)
- We also assume that players are rational and know the structure, the rules, and the payoffs of the game. These are called games with perfect information.

Definition of a Game

A Normal (or Strategic) Form Game consists of:

- A set of n players denoted by: N= $\{i_1, i_2, \dots, i_n\}$
- Each player $i, i \in N$, has a pure strategy set S_i
- For each player i there is payoff function π^i that assigns a real number representing the utility player i will obtain for all possible combinations of strategies chosen be all players of the game $S = S_1 \times S_2 \times \cdots \times S_n$
- We will denote by $s_i \in S_i$ a strategy for player i, and by $s_{-i} = (s_1, s_2, \dots, s_{i-1}, s_{i+1}, \dots, s_n)$ the strategies of the other players
- In this notation, $(s_i, s_{i-1}) \in S$ denotes a strategy profile (or outcome) of the game (i.e. the specific strategies chosen by all the players)

Example of a Game

Alice and Bob are playing the following card game. Each of them has a red card and a black card. Playing the red card give 400 points to the other player (i.e. if Alice plays the red card, Bob gets 400 points). Playing the black card give 300 points to yourself (i.e. if Alice plays the black card, she gets 300 points). Both players reveal the card they play at the same time.

Example of a Game

- Consider the game $G = \{N, (S_i)_{i \in N}, (\pi_i)_{i \in N}\}$
  - N={Alice,Bob}
  - $S_{Alice} = S_{Bob} = \{Red, Black\}$
  - There were 4 possible outcomes *(strategy profiles)*: (Red, Red), (Red, Black), (Black, Red), (Black, Black)
  - The fuction π_i needs to specify how much each player would earn in each of the possible outcomes
- We can represent all this in a table

Representation in Matrix Form

		Bob	
		Red	Black
Alice	Red	(400, 400)	(0, 700)
	Black	(700, 0)	(300, 300)

- Normal form games are usually represented in a matrix. The matrix above shows the game in the example
- This game above is typically referred as the prisoners' dilemma
- This simple game applies to many settings. For example, firms engaging in price wars, or the game we played earlier today

Take Away

- We discussed thick markets and how they lead to an equilibrium of demand and supply
  - And the equilibrium was efficient as it maximizes economic welfare
- We started talking about game theory
  - How a strategic (or normal) form game is defined
  - How it is usually represented in matrix form
- These two concepts will be important throughout the semester:
  - We want markets to be efficient. With prices and WTA/WTP is easy to determine. Without prices we will have to use different concepts.
  - When studying markets, we want a framework to analyze agents' behavior. Game theory is ideal for this.