Econ 301: Microeconomic Analysis

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Equilibrium

Market Supply

- Now we consider how the demand side interacts with the supply side
  - Guiding principle: equilibrium
- For now, assume that $S(p)$ measures how much producers are willing to supply in aggregate at price p
  - Assume $S(p)$ is upward sloping

Setting up Equilibrium

- What do we mean when we say equilibrium?
  - An agent (consumer or producer) is *best-responding* if they are choosing their best possible action given what everyone else is choosing
  - We are in an *equilibrium* if all agents are best-responding
- We also assume that agents are *price-takers*
  - Small agents have negligible market power
  - We also call this a *competitive equilibrium*
  - Contrast with monopoly, oligopoly

Market Equilibrium

Definition

A market equilibrium is characterized by a price and quantity (p^*, q^*) such that $q^* = D(p^*) = S(p^*)$.

- Why is this an equilibrium?
- Consider price $p' < p^*$
  - Some suppliers can sell at a price between p' and p^* to willing consumers
  - This will push price up to p^*
- Consider price $p'' > p^*$
  - Some suppliers who would like to sell at this price can't find consumers
  - Suppliers would be willing to lower price to find buyers
  - This will push price down to p^*
- Consider price $p = p^*$
  - No suppliers want to raise or lower their prices
  - No consumers want to enter/leave market

Equilibrium with Inverse Supply and Demand

- Recall we could invert demand so that we talked about price as a function of quantity
  - Call inverse demand $P_D(q)$
- We can do the same with supply
  - Call inverse demand $P_S(q)$
- Equilibrium condition then becomes $P_S(q^*) = P_D(q^*) = p^*$

Example: Linear Supply and Demand

- Let demand and supply be given by

$$\begin{aligned} D(p) &= a - bp \\ S(p) &= c + dp \end{aligned}$$

- What are equilibrium price and quantity?
- Set demand and supply equal to find p^*:

$$\begin{aligned} a - bp &= c + dp \\ p^* &= \tfrac{a-c}{b+d} \end{aligned}$$

- Plug in to find q^*:

$$\begin{aligned} q^* &= a - b\tfrac{a-c}{b+d} \\ &= \tfrac{ad+bc}{b+d} \end{aligned}$$

Equivalence of Inverse Supply and Demand

- We can get same solution by inverting supply and demand:

$$
\begin{aligned}
P_D(q) &= \tfrac{a-q}{b} \\
P_S(q) &= \tfrac{q-c}{d}
\end{aligned}
$$

- Set inverse supply and demand equal to find q^*:

$$
\begin{aligned}
\frac{a-q}{b} &= \tfrac{q-c}{d} \\
q^* &= \tfrac{ad+bc}{b+d}
\end{aligned}
$$

- Plug in to find price:

$$
p^* = \frac{a - \frac{ad+bc}{b+d}}{b} = \frac{ab + ad - ad - bc}{b(b+d)} = \frac{a-c}{b+d}
$$

Example: Horizontal and Vertical Supply

- Vertical (fixed) supply
  - Producers willing to supply the same amount $\hat{q}$ at any price
  - Supply curve is vertical at $\hat{q}$
  - In equilibrium, quantity will be fixed by supply side ($q^* = \hat{q}$) but price determined by demand
  - Example? Land
- Horizontal supply
  - Producers willing to supply any amount at a certain price $\hat{p}$
  - Supply curve is horizontal at $\hat{p}$
  - In equilibrium, price is fixed by supply side ($p^* = \hat{p}$) but quantity determined by demand
- In general, p^* and q^* determined jointly by supply and demand

Vertical and Horizontal Supply Graphically

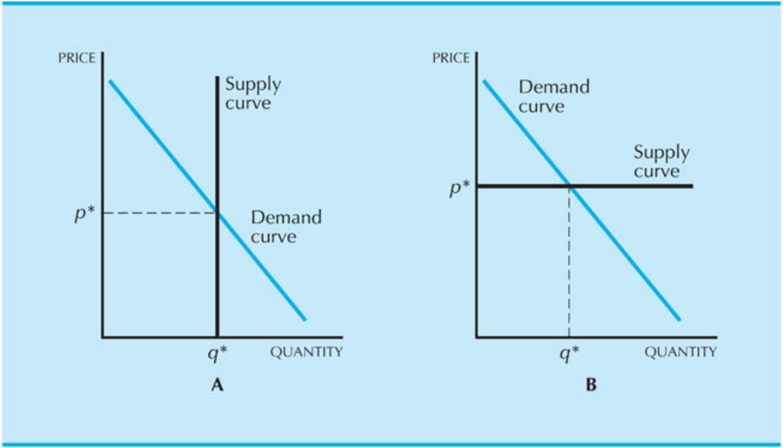

Figure 16.1

Taxes and Deadweight Loss

Taxes

- A tax on an item means that consumers pay a different price than produces receive for the good
  - We say taxes introduce a *wedge* between prices
  - Now two prices where there was one before
  - For taxes, we have $P_D > P_S$
- Because we now have two prices, taxes slightly change our equilibrium conditions
  - Quantity tax t: $P_D(q^*) = P_S(q^*) + t$
  - Value tax τ: $P_D(q^*) = (1 + \tau)P_S(q^*)$
- Importantly, it doesn't matter who actually sends the tax in to the government
  - Can have producer send in tax payments, e.g. like with sales tax
  - Can have consumer send in tax payments, e.g. like with income tax
- However, shape of supply and demand curves will affect who is made worse-off by taxes

Equilibrium Effect of a Quantity Tax

- Under a quantity tax, we have different prices (p_D^* and p_S^*) but same quantity bought and sold
- Therefore, equilibrium now has two conditions:
  1. $D(p_D^*) = S(p_S^*)$
  2. $p_D^* = p_S^* + t$ (we are assuming quantity tax t)
- We can combine this to one equation:

$$D(p_S^* + t) = S(p_S^*)$$

- Alternatively, we can work with inverse demand and supply, in which case equilibrium condition is

$$P_D(q^*) = P_S(q^*) + t$$

- Graphically, we search for the quantity where demander's price and supplier's price are separated by an amount equal to the tax

Effect of a Tax Graphically

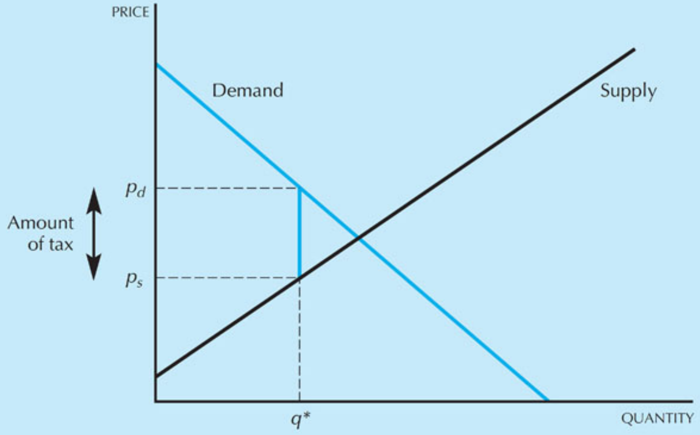

Figure 16.4

Example: Taxation with Linear Supply

- Let demand and supply be linear as in previous example

$$\begin{aligned} D(p) &= a - bp_D \\ S(p) &= c + dp_S \end{aligned}$$

- What are equilibrium prices and quantities with quantity tax t?
- Set quantities equal:

$$\begin{aligned} a - bp_D &= c + dp_S \\ a - b(p_S + t) &= c + dp_S \end{aligned}$$

- Solving we find

$$\begin{aligned} p_S^* &= \tfrac{a-c-bt}{b+d} < \tfrac{a-c}{b+d} \\ p_D^* &= \tfrac{a-c+dt}{b+d} > \tfrac{a-c}{b+d} \\ q^* &= \tfrac{ad+bc-bdt}{b+d} < \tfrac{ad+bc}{b+d} \end{aligned}$$

Elasticity of Supply and Producer's Surplus

- For what follows, we need to introduce supply-side analogues of two big ideas from consumer theory
- Supply elasticity
  - Just as with demand, we want to know how much supply changes with price
  - Define *elasticity of supply* as $\eta = \frac{p_S}{q_S}\frac{dq_S}{dp_S} \approx \frac{p_S}{q_S}\frac{\Delta q_S}{\Delta p_S}$
- Producer surplus
  - Recall consumer surplus (CS) is area between demand curve and market price
  - Producer surplus (PS) is defined as area between supply curve and market price
  - Concerned mostly with changes in surplus: ΔPS

Deadweight Loss

- The *total surplus* is the sum of consumer surplus and producer surplus
$$TS = PS + CS$$
  - Often concerned with change in total surplus, $\Delta TS = \Delta CS + \Delta PS$
- The *tax revenue* given by
$$TR = tq^* = q^*(p_D^* - p_S^*)$$
- The *deadweight loss* of the tax is the sum of change in surplus, minus the tax revenue
$$DWL = |\Delta TS| - TR$$

Tax Revenue and Deadweight Loss

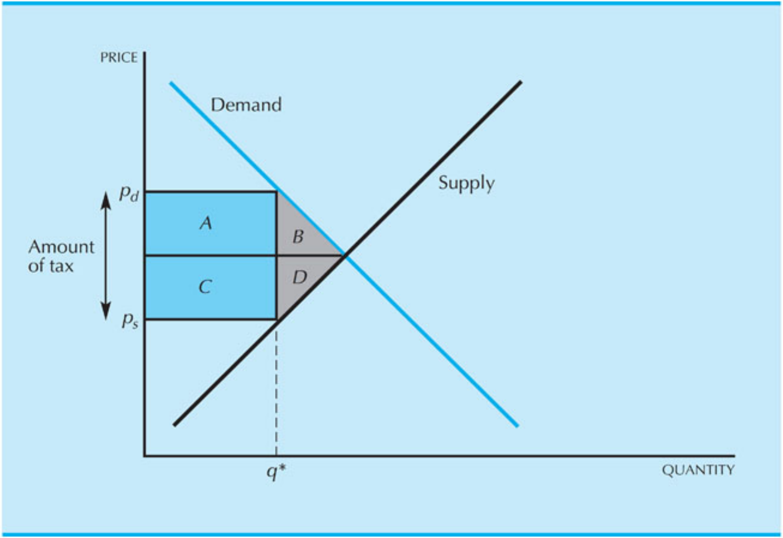

Figure 16.7

Passing Along A Tax: Motivating Examples

- What is the effect of a quantity tax when we have horizontal supply at price $\hat{p}$?
  - Before tax, we have $p_S^* = p_D^* = \hat{p}$
  - After tax, must still have $p_S^* = \hat{p}$, ie no effect on producers' price
  - So tax raised consumer price to $p_D^* = \hat{p} + t$
  - We say *tax burden* borne entirely by consumers
  - Note that supply is perfectly elastic in this case
- What is the effect of a quantity tax when we have vertical supply?
  - Must have demand unchanged
  - Therefore producer price must drop by t
  - Consumer price unaffected
  - So tax burden borne entirely by producers
  - Note that supply is perfectly inelastic in this case

Effect of a Tax On Horizontal and Vertical Supply

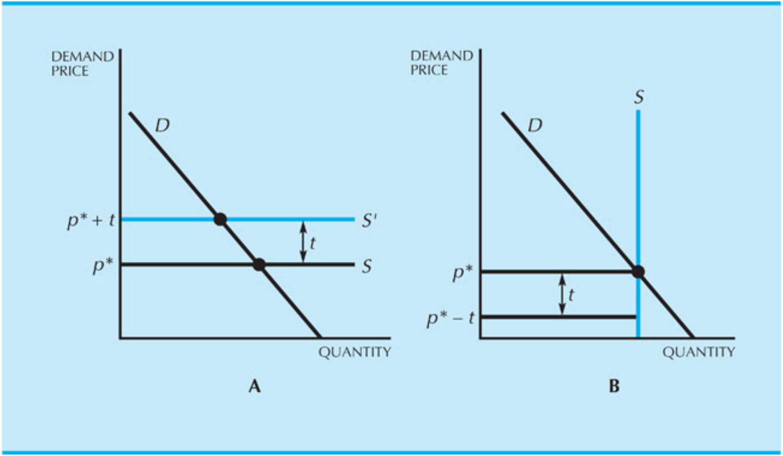

Figure 16.5

Tax Burden in General

- We need a way to compare change in consumer price and change in producer price before and after tax
- From our definitions of elasticity:

$$\frac{\Delta q_S}{q_S} = \eta \frac{\Delta p_S}{p_S}$$
$$\frac{\Delta q_D}{q_D} = \epsilon \frac{\Delta p_D}{p_D}$$

- Note that
  - Quantities are the same for consumers and producers in both pre- and post-tax equilibria, so $\frac{\Delta q_S}{q_S} = \frac{\Delta q_D}{q_D}$
  - In the pre-tax equilibrium, $p_S = p_D$
- Thus we can rearrange to find that

$$\frac{\Delta p_D}{\Delta p_S} = \frac{\eta}{\epsilon}$$

Relative Tax Burden

- Can also be shown that

$$\frac{dp_D}{dt} = \frac{\eta}{\eta - \epsilon}$$
$$\frac{dp_S}{dt} = \frac{\epsilon}{\eta - \epsilon}$$

- Thus the party with the larger elasticity (in magnitude) will bear less of the tax burden
- Eg When supply is perfectly elastic, tax burden entirely on consumers