An Economic Theory Masterclass

Part II: The Supply and Demand Paradigm

Lones Smith

March 3, 2020

The Supply and Demand Paradigm

- We consider a competitive price-taking environment summarized by a (usually upward sloping) supply curve and (usually downward sloping) demand curves.
- Each curve reflects both extensive and intensive margins.
- These two curves answer out-of-equilibrium hypothetical "what if" questions: what would the supply and demand be at any other price?
- By parsing our logic into supply and demand, we can compartmentalize our analysis, and make clearer predictions

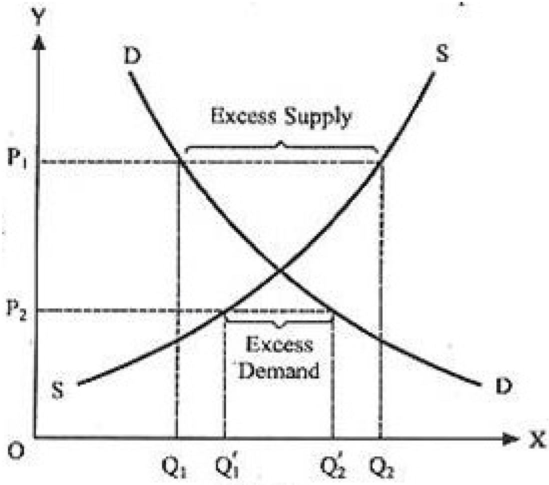
Stability — Does Competitive Equilibrium Happen?

- Supply price and quantity: P_S and Q_S
- Demand price and quantity: P_D and Q_D
- If the world is changing, should market equilibrium arise?
- We explore the adjustment *tatonnement process* ("groping")
- Walrasian price stability
  - price adjustment process of fictional double auctioneer
  - If *net demand* is positive at some price, then the price rises
  - If net demand is negative, then the price decreases

  $\Rightarrow$ change in the price shares the sign of $Q_D - Q_S$.
  - Source: Leon Walras, *Elements of Pure Economics* (1874)
- Marshallian quantity stability
  - If demand price exceeds supply price at some quantity, then supply quantity rises, and conversely
  - Suppliers raise/reduce supply of high/low demand goods

  $\Rightarrow$ change in the quantity shares the sign of $P_D - P_S$.

Walrasian and Marshallian Stable



Stability with Linear Supply and Demand

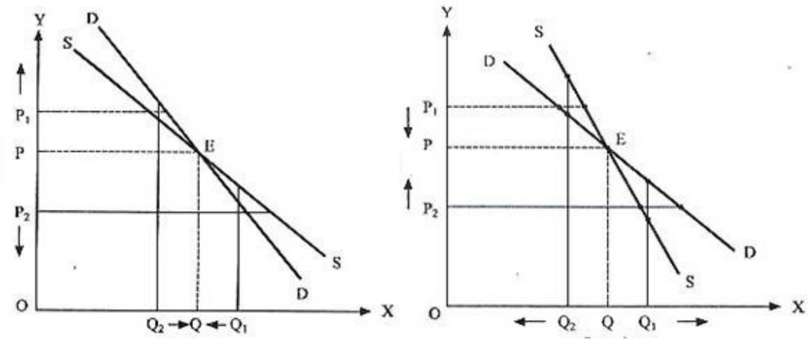
- linear supply $P_S = a_S + b_S Q_S$ and demand $P_D = a_D - b_D Q_D$.
- Demand slopes down: $b_D > 0$. So when $P_D = P_S = P$, we have

$$Q_D - Q_S = \frac{a_D}{b_D} + \frac{a_S}{b_S} - P\left(\frac{1}{b_D} + \frac{1}{b_S}\right)$$

- Walrasian price stability:
  - $Q_D - Q_S$ falls in P at $P_D = P_S = P$, or $1/b_D + 1/b_S > 0$.
- Marshallian quantity stability:
  - $P_D - P_S = a_D - a_S - (b_D + b_S)Q$ falls in Q iff $b_D + b_S > 0$
- Both hold with falling demand and rising supply $(b_D, b_S > 0)$
- But if the supply curve slopes down,
  - Walrasian price stability holds iff $b_D < |b_S|$
  - Marshallian quantity stability holds iff $b_D > |b_S|$

  $\Rightarrow$ for a slightly backward bending supply curve, $|b_S|$ is large, and so equilibrium is Walrasian but not Marshallian stable.

Stability: Downward-sloping Demand and Supply

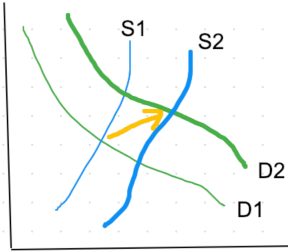


- demand steeper than supply ⇒ Walrasian unstable and Marshallian stable
- supply steeper than demand ⇒ Walrasian stable and Marshallian unstable

Comparative Statics Analysis

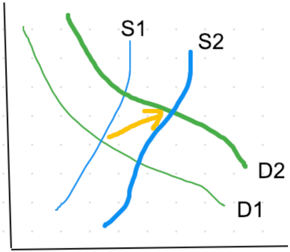
- Supply and demand are not just static notions
- Units are per week, or per day, etc.
- Dynamics: Heraclitus — Panta Rhei
  - “All entities move and nothing remains still”
- “No man ever steps in the same river twice”

Comparative Statics Analysis



- Standard assumption: monotone dynamics from one steady-state to the next
  $\Rightarrow$ comparing the two static situations is informative

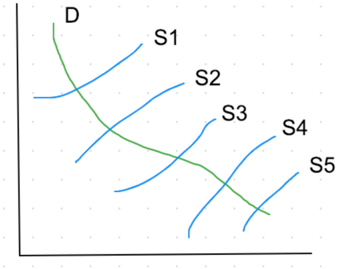
Comparative Statics Analysis



- Standard assumption: monotone dynamics from one steady-state to the next
  ⇒ comparing the two static situations is informative
- Famous counter example: "overshooting" model of Dornbusch (1976) in international finance (cited 6600 times)
  - After an unexpected influx of new money, the domestic price level adjusts slowly, but the exchange rate can adjust quickly.
  - Convergence to new steady-state is nonmonotone (overshoots)

Identification of Supply and Demand Curves

- price and quantity reflect both supply and demand.
- If you wanted to "identify" the demand curve, you find something that just shifts supply and leaves demand invariant.
- With enough variation in supply, we can identify the demand.
- Likewise, variation in demand but not supply would allow one to pin down the supply curve.



Elasticities Review

- Review: More elastic supply or demand has larger quantity response for any price change
- Change is proportionate: $\varepsilon = (dQ/dP)(P/Q)$

$\Rightarrow$ Elasticity is unit-free!

- When $|\varepsilon| > 1$, we call the supply or demand elastic
- Demand elasticity is spoken of in absolute terms!

Elasticities Review

- Review: More elastic supply or demand has larger quantity response for any price change
- Change is proportionate: $\varepsilon = (dQ/dP)(P/Q)$

$\Rightarrow$ Elasticity is unit-free!

- When $|\varepsilon| > 1$, we call the supply or demand elastic
- Demand elasticity is spoken of in absolute terms!
- Le Chatelier's Principle: long run elasticity $>$ short run elasticity, since the short run is more constrained
- Q1: Characterize constant elasticity rising supply curves.

Elasticities Review

- Review: More elastic supply or demand has larger quantity response for any price change
- Change is proportionate: $\varepsilon = (dQ/dP)(P/Q)$

$\Rightarrow$ Elasticity is unit-free!

- When $|\varepsilon| > 1$, we call the supply or demand elastic
- Demand elasticity is spoken of in absolute terms!
- Le Chatelier's Principle: long run elasticity $>$ short run elasticity, since the short run is more constrained
- Q1: Characterize constant elasticity rising supply curves. Answer: Upward sloping linear supply curves

Elasticities Review

- Review: More elastic supply or demand has larger quantity response for any price change
- Change is proportionate: $\varepsilon = (dQ/dP)(P/Q)$

$\Rightarrow$ Elasticity is unit-free!

- When $|\varepsilon| > 1$, we call the supply or demand elastic
- Demand elasticity is spoken of in absolute terms!
- Le Chatelier's Principle: long run elasticity $>$ short run elasticity, since the short run is more constrained
- Q1: Characterize constant elasticity rising supply curves. Answer: Upward sloping linear supply curves
- Q2: Characterize constant elasticity falling demand curves.

Elasticities Review

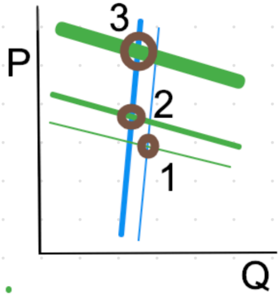
- Review: More elastic supply or demand has larger quantity response for any price change
- Change is proportionate: $\varepsilon = (dQ/dP)(P/Q)$

$\Rightarrow$ Elasticity is unit-free!

- When $|\varepsilon| > 1$, we call the supply or demand elastic
- Demand elasticity is spoken of in absolute terms!
- Le Chatelier's Principle: long run elasticity $>$ short run elasticity, since the short run is more constrained
- Q1: Characterize constant elasticity rising supply curves. Answer: Upward sloping linear supply curves
- Q2: Characterize constant elasticity falling demand curves. Answer: Hyperbolic downward sloping curves: $P = Q^{1/\varepsilon}$

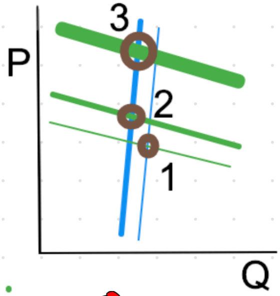
Large Price Volatility in the Oil Market

- Consider the facts of the oil or gasoline market
  - Huge price volatility
  - Minimal quantity volatility
  - Slow change in fundamentals



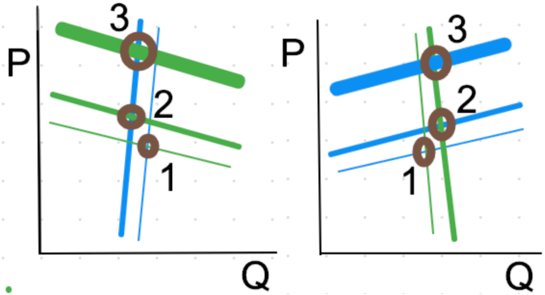
Large Price Volatility in the Oil Market

- Consider the facts of the oil or gasoline market
  - Huge price volatility
  - Minimal quantity volatility
  - Slow change in fundamentals



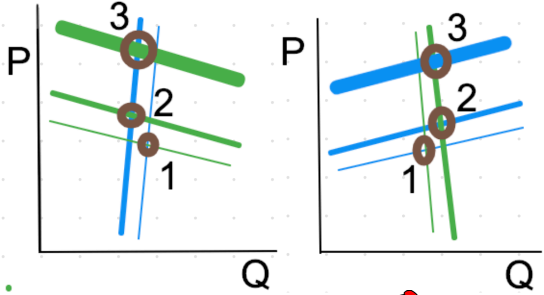
Large Price Volatility in the Oil Market

- Consider the facts of the oil or gasoline market
  - Huge price volatility
  - Minimal quantity volatility
  - Slow change in fundamentals



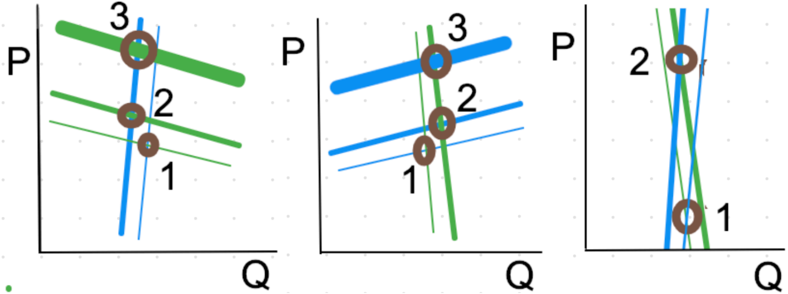
Large Price Volatility in the Oil Market

- Consider the facts of the oil or gasoline market
  - Huge price volatility
  - Minimal quantity volatility
  - Slow change in fundamentals



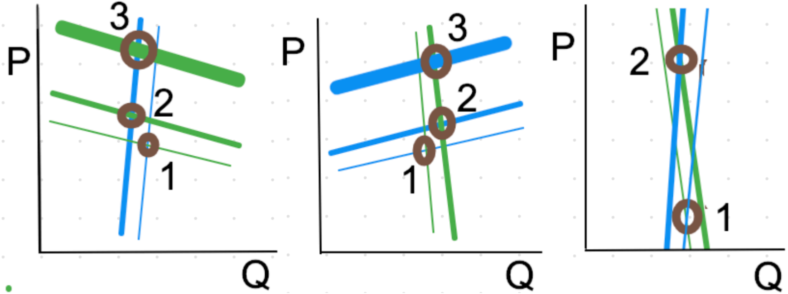
Large Price Volatility in the Oil Market

- Consider the facts of the oil or gasoline market
  - Huge price volatility
  - Minimal quantity volatility
  - Slow change in fundamentals



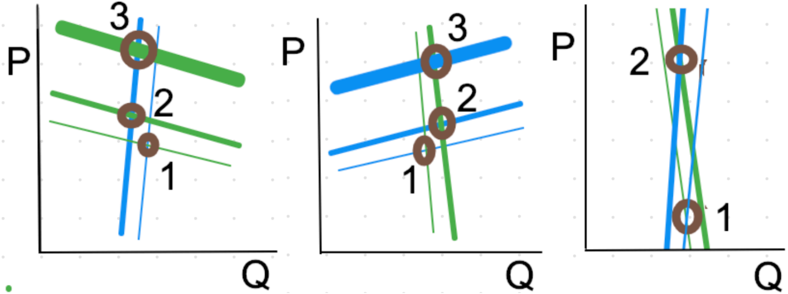
Large Price Volatility in the Oil Market

- Consider the facts of the oil or gasoline market
  - Huge price volatility
  - Minimal quantity volatility
  - Slow change in fundamentals



Large Price Volatility in the Oil Market

- Consider the facts of the oil or gasoline market
  - Huge price volatility
  - Minimal quantity volatility
  - Slow change in fundamentals



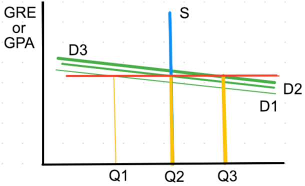
- Lesson 1: Small fundamentals shifts cause large proportionate price changes iff both supply and demand are highly inelastic.
- Lesson 2: Inelastic supply or demand ⇒ low quantity volatility

Large Quantity Volatility

- Lesson 3: Small fundamentals changes can lead to large quantity changes iff supply and demand are highly elastic.
- Lesson 4: Elastic supply or demand $\Rightarrow$ low price volatility

Large Quantity Volatility

- Lesson 3: Small fundamentals changes can lead to large quantity changes iff supply and demand are highly elastic.
- Lesson 4: Elastic supply or demand $\Rightarrow$ low price volatility
- College admissions is an "implicit market", where the "price" is the admission bar (Try to formalize why this is true.)
- Source: Chade, Lewis, and Smith (2014), "Student Portfolios and the College Admissions Problem" (in canvas)



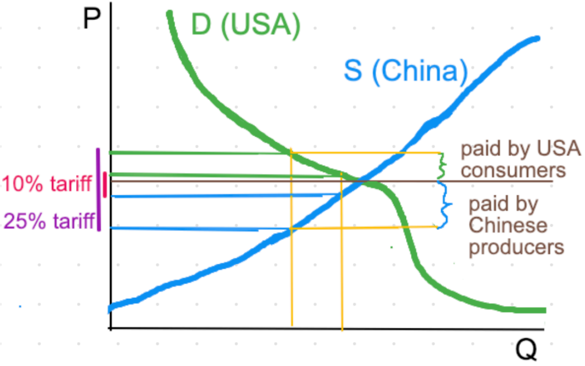
- Without waitlisting, as in PhD admissions, acceptance bar mistakes can lead to massive changes in acceptance rates.
- 2017: UC-Irvine unadmitted 499 students

Shared Incidence or Tax or Tariff

- Trump added a 10% tariff on Chinese imports, to rise to 25%

⇒ wedge between supply and demand prices: $P_D > P_S$.

- Incidence: Who pays the tariff or tax?
- "China is paying us billions of dollars in tariffs." — Trump

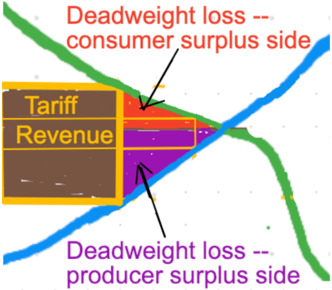


Deadweight Loss of Tax

- Double auctions: No effect of small tax! Here: small effect.
- Lost gains from trade = lost consumer + producer surplus
- Assume tariff revenue is socially neutral: gain to government balances loss to producers or consumers

$\Rightarrow$ deadweight loss (excess burden) of tariff is red + purple

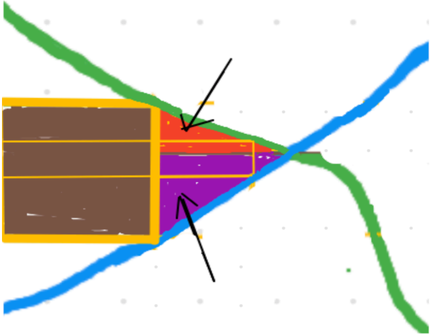
- Tariff revenue rises proportionately less than the tariff rise



←Taxes erase marginal trades

Changes in the Deadweight Loss of Tax

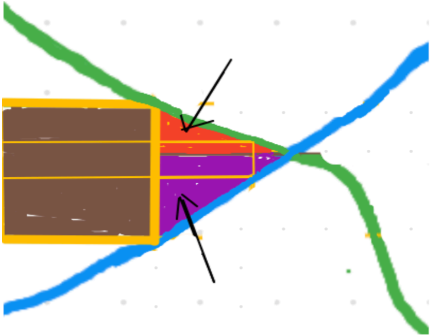
- The deadweight loss of a tariff increases in the quantity reduction, larger with more inelastic demand or supply

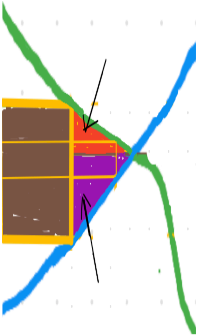


(more elastic S and D)
(longrun?)

Changes in the Deadweight Loss of Tax

- The deadweight loss of a tariff increases in the quantity reduction, larger with more inelastic demand or supply





(less elastic S and D)
(shortrun?)

Optimal Taxes: the Ramsey Inverse Elasticity Rule

- Tax revenue falls when the tax rises if the demand is elastic:

$$[Q(P+\tau)\tau]' = Q(P+\tau) + Q'(P+\tau)\tau = Q(P+\tau)[1+\varepsilon \frac{\tau}{P+\tau}]$$

$\Rightarrow$ never tax an elastically demanded good

- Optimal taxes seek to minimize deadweight losses, and so focus on inelastically demanded or supplied goods.
- Ramsey (1927): Minimize the social cost of raising revenue R

$$\max V(p+\tau, I) \text{ s.t. } \tau \cdot x(p+\tau, I) \geq R$$

- Ramsey inverse elasticity rule: "taxes should be proportional to the sum of the reciprocals of its supply and demand elasticities"
- In other words, governments should not tax elastically demanded goods or elastically supplied goods.

Optimal Taxes

- Governments know to tax inelastically supplied resources:
  - Oil taxes, mineral taxes
  - existence tax: poll tax (head tax) in Britain (fertility impact?)
  - wealth taxes are usually real estate, or at death taxes
  - millionaire tax? billionaire tax?

Optimal Taxes

- Governments know to tax inelastically supplied resources:
  - Oil taxes, mineral taxes
  - existence tax: poll tax (head tax) in Britain (fertility impact?)
  - wealth taxes are usually real estate, or at death taxes
  - millionaire tax? billionaire tax?
- More rationality $\leftrightsquigarrow$ more elastic response
  - Example: Does income reflect effort, ability, luck or networks?
  - Tax luck or ability or networks — inelastically supplied.
  - "The harder I work, the luckier I get." — Sam Goldwyn

Taxes — Basic Accounting Insights

- Tariff or sales or *ad valorem* tax: $P_D(Q) = P_S(Q) + \tau P_S(Q)$
- *Specific tax* τ: $P_D(Q) = P_S(Q) + \tau$
- Wisconsin specific tax examples
  - gas tax: state 32.9¢ and federal 18.4¢ per gallon
  - Beer: 6¢/gallon and wine: 25¢/gallon and liquor: $3.25/gallon
  - Also exists for cigarettes
- A sales tax is paid by demanders ⇒ down-shift in demand

Taxes — Basic Accounting Insights

- Tariff or sales or *ad valorem* tax: $P_D(Q) = P_S(Q) + \tau P_S(Q)$
- *Specific tax* τ: $P_D(Q) = P_S(Q) + \tau$
- Wisconsin specific tax examples
  - gas tax: state 32.9¢ and federal 18.4¢ per gallon
  - Beer: 6¢/gallon and wine: 25¢/gallon and liquor: $3.25/gallon
  - Also exists for cigarettes
- A sales tax is paid by demanders ⇒ down-shift in demand
- VAT is paid by suppliers (hidden in price) ⇒ up-shift in supply

Theorem (Tax Irrelevance Theorem)

Regardless of whether demand or supply pays the tax, the demand and supply prices, market quantity, and efficiency loss are the same.

Taxes — Basic Accounting Insights

- Tariff or sales or *ad valorem* tax: $P_D(Q) = P_S(Q) + \tau P_S(Q)$
- *Specific tax* τ: $P_D(Q) = P_S(Q) + \tau$
- Wisconsin specific tax examples
  - gas tax: state 32.9¢ and federal 18.4¢ per gallon
  - Beer: 6¢/gallon and wine: 25¢/gallon and liquor: $3.25/gallon
  - Also exists for cigarettes
- A sales tax is paid by demanders ⇒ down-shift in demand
- VAT is paid by suppliers (hidden in price) ⇒ up-shift in supply

Theorem (Tax Irrelevance Theorem)

Regardless of whether demand or supply pays the tax, the demand and supply prices, market quantity, and efficiency loss are the same.

- Specific tax is easier to analyze: parallel demand / supply shift

Tax Incidence and Elasticities

- Incidence: The more inelastic side of the market pays more of a tax and benefits more from a subsidy
- Demand elasticity $\varepsilon = (dQ_D/dP_D)(P_D/Q_D) < 0$
- Supply elasticity $\eta = (dQ_S/dP_S)(P_S/Q_S) > 0$

Theorem (Incidence Theorem)

The share of a small tax paid by demand is $\frac{\eta}{\eta-\varepsilon} \leq 1$.

- *Proof*: Impose a small excise tax $\tau \equiv P_D - P_S > 0$
- Markets clear: $dQ_S/Q = dQ_D/Q$.

$$\Rightarrow \qquad \eta\frac{dP_S}{P_S} = dQ_S/Q = dQ_D/Q = \epsilon\frac{dP_D}{P_D}$$

$$\Rightarrow \qquad \tau = dP_D - dP_S = dP_D - \frac{\epsilon}{\eta}\frac{dP_D}{P_D}P_S \approx dP_D - \frac{\epsilon}{\eta}dP_D$$

since $P_D/P_S = (P_S + \tau)/P_S \approx 1$ with error similar size to τ

$$\Rightarrow dP_D \approx \frac{\eta}{\eta - \epsilon}\tau > 0 \quad \text{and} \quad dP_S \approx \frac{\epsilon}{\eta - \epsilon}\tau < 0$$

Deadweight Loss for Small Taxes

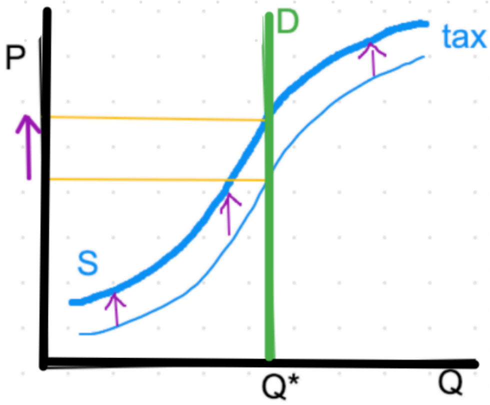
- Since $\varepsilon = (dQ_D/dP_D)(P_D/Q_D)$, the quantity changes by

$$dQ = \epsilon \frac{dP_D Q}{P_D} \approx \epsilon \left(\frac{\eta}{\eta - \epsilon}\right) \tau \left(\frac{Q}{P_D}\right) = \left(\frac{1}{\frac{1}{\epsilon} - \frac{1}{\eta}}\right) \tau \left(\frac{Q}{P_D}\right)$$

- Hence, the deadweight loss is the area of the standard triangle:

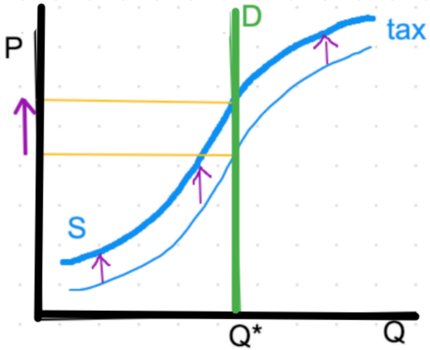
$$\frac{1}{2}(dQ)(dP_D - dP_S) = \frac{1}{2}(dQ)\tau = \left(\frac{1}{\frac{1}{\epsilon} - \frac{1}{\eta}}\right) \left(\frac{Q}{2P_D}\right) \tau^2$$

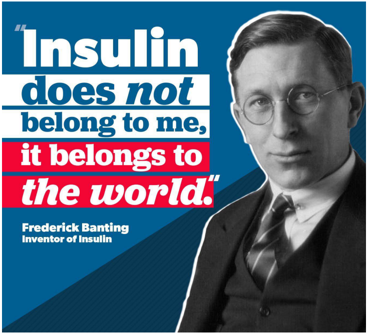
Impact of an Insulin Tax



- By the tax incidence theorem, we can apply the tax to supply
- There is no deadweight loss of the tax, as $Q = Q^*$ fixed!

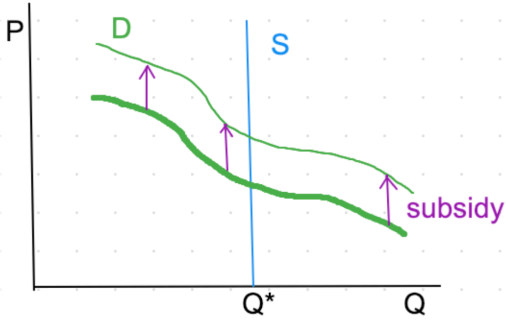
Impact of an Insulin Tax





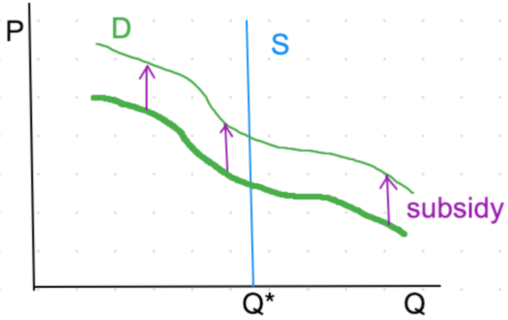
- By the tax incidence theorem, we can apply the tax to supply
- There is no deadweight loss of the tax, as $Q = Q^*$ fixed!
- In fact, insulin was sold for $1 by Canadians Banting and Best to the University of Toronto.
- insulin has new patents, and its price has leapt up!

Michigan College Subsidy Eliminated



- In 2009, Michigan ended the Promise Scholarship program, giving 96,000 in-state students up to $4,000 for college
- Who fought to keep it? Colleges!

Michigan College Subsidy Eliminated



- In 2009, Michigan ended the Promise Scholarship program, giving 96,000 in-state students up to $4,000 for college
- Who fought to keep it? Colleges!
- Another fixed supply context: the "death effect" for artists
- Hyperinflations

Application of Supply and Demand to Rollover Lotteries

- A *classic lottery* has a unique winner with a fixed prize.
- In a Genoese lottery, people pick their own numbers: If no one wins, the prize rolls over; if many win, the prize is shared.
- Why do people gamble? Consider a quasi-linear model: People gamble if the expected utility of winnings plus the thrill of playing the lotto exceeds the ticket price.
- Rollovers can identify this model.
- Assume risk neutrality.
- Let M denote the number of possible lotto numbers ("odds"), and so the winning chance for the jackpot is $1/M$.
  - $M \approx 259000000$ for Megamillions
  - $M \approx 292000000$ for Powerball.
- Ticket price p and lottery taxes $\tau \in (0, 1)$
- Let J denote the remaining jackpot of last period.
- Classic lotto prize of W

Expected Lotto Winnings

- Assume S tickets sold for a drawing (our quantity)

$\Rightarrow$ The expected number of winners is $\mu = S/M$.

- $Q(k|M,S) = P(k \text{ winners}) = C(S,k)(1/M)^k(1-1/M)^{S-k}$
- Accounting for expected gains from the classic lotto and possibly shared jackpot among S ticket buyers:

$$\begin{aligned} E(\text{ticket winnings}) &= W/S + \frac{1}{M}\sum_{k=0}^{S}\frac{J+p(1-\tau)S}{k+1}Q(k|M,S-1) \\ &\approx W/S + [J/S + p(1-\tau)][1-e^{-S/M}] \end{aligned}$$

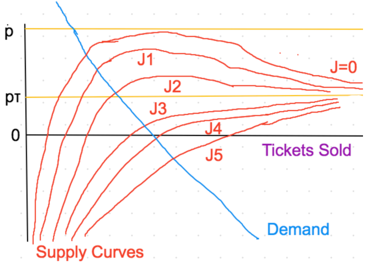
(using the Poisson approximation to the Binomial)

- We will rephrase this as the "supply" of expected ticket losses:

$$E(\text{ticket losses}) = p - W/S - [J/S + p(1-\tau)][1-e^{-S/M}]$$

- We treat this as an implicit market where the expected losses from tickets as the "net price" of thrill of the lotto experience.

Supply Curve of Lotto Losses, as the Jackpot Rises



- The supply curves shift down as the jackpot rises, and is negative for large jackpots.
- Each supply curve asymptotes to $p\tau$ as $S \uparrow \infty$
- More sold tickets
  - (a) inflates the next jackpot, which depresses supply losses
  - (b) raises the prize sharing chance, increases supply losses
- The demand curve is the locus of lotto losses for the thrill
- Rollovers just shift the supply curve and so identify demand

Supply / Demand Curves: Intensive and Extensive Margins

- We introduced the supply and demand in the double auction
- There, all gains from trade — namely, producer plus consumer surplus — reflect heterogeneity.
- We now allow a realistic intensive margin,
  - Output from every firm, and consumption from every consumer, increases in the market price
  - the producer surplus also increases in cost convexity, and consumer surplus increases in preference convexity
- We just flesh out the logic for supply curves

Supply Curves: Intensive and Extensive Margins

- A cost is **escapable** if can be avoided.
- Otherwise, it is inescapable or "sunk".
- Since such costs are unavoidable, they cannot possibly affect behavior, and should be ignored in all optimizations

= essence of dynamic programming

Supply Curves: Intensive and Extensive Margins

- A cost is **escapable** if can be avoided.
- Otherwise, it is inescapable or "sunk".
- Since such costs are unavoidable, they cannot possibly affect behavior, and should be ignored in all optimizations

= essence of dynamic programming

- A **fixed cost** is invariant to the quantity.
- A **variable cost** is not.
- So variable costs are escapable, since one can adjust them down to zero by not producing anything.

Supply Curves: Intensive and Extensive Margins

- A cost is **escapable** if can be avoided.
- Otherwise, it is inescapable or “sunk”.
- Since such costs are unavoidable, they cannot possibly affect behavior, and should be ignored in all optimizations

= essence of dynamic programming

- A **fixed cost** is invariant to the quantity.
- A **variable cost** is not.
- So variable costs are escapable, since one can adjust them down to zero by not producing anything.
- Marginal costs ⇔ intensive margins
- Average costs ⇔ extensive margins

Short, Medium, Long Runs

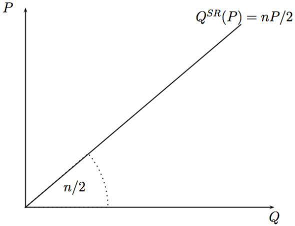
- We use static models to capture dynamic notions
- As the run increases, there are more choice margins, and so inescapable costs $\rightsquigarrow$ escapable (e.g., rental contracts end).
- **Short run**
  - fixed costs are inescapable; cost function is just variable costs
  - Insufficient time for entry; reducing output to zero
- **Long run**
  - All costs are escapable, and so are included in the cost function
  - firms enter if there are profits to be made and otherwise exit
  - John Maynard Keynes: "In the long run we are all dead"
  - JMK: ignoring dynamics (eg. quantity theory of money) unwise
- **"Medium run"**
  - more decision margins available, and so more costs escapable, than in the short run, and fewer than in the long run.

Short, Medium, Long Runs

- We use static models to capture dynamic notions
- As the run increases, there are more choice margins, and so inescapable costs $\rightsquigarrow$ escapable (e.g., rental contracts end).
- **Short run**
  - fixed costs are inescapable; cost function is just variable costs
  - Insufficient time for entry; reducing output to zero
- **Long run**
  - All costs are escapable, and so are included in the cost function
  - firms enter if there are profits to be made and otherwise exit
  - John Maynard Keynes: "In the long run we are all dead"
  - JMK: ignoring dynamics (eg. quantity theory of money) unwise
- **"Medium run"**
  - more decision margins available, and so more costs escapable, than in the short run, and fewer than in the long run.
- **Industry supply curve**
  - price-quantity locus (P, Q), such that, the allowable firms — i.e., the existing firms in the short run, or all potential firms in the long run — profitably produce Q taking price P as given
  - Note: price-taking behavior is incredible with few firms

Example of Supply with Homogeneous Firms

- Cost functions $C(q) = 1 + q^2$ (fixed cost 1 & variable cost q^2)
- Optimal production: $P = C'(q) = 2q \Rightarrow$ output $q = P/2$.
- Short run supply with n firms: $Q_n^{SR}(P) = nq = nP/2$ 😱



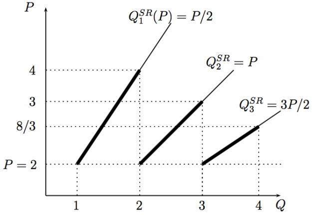
- The supply curve rises simply due to cost convexity.
- The source of all profits is cost convexity (diminishing returns)
- This intensive margin effect — firms sell more with a higher price — was not present with double auctions

Sawtooth Long Run Supply

- For the long run, firms earn nonnegative profits with all costs escapeable, and no firm wishes to enter or exit.
- Entry $\Rightarrow$ long run supply is more elastic (Le Chetalier)
- The least price needed for production is 2, since:

$$C'(q) = P \geq C(q)/q = \frac{1}{q} + q \Rightarrow 2q \geq \frac{1}{q} + q \Rightarrow q \geq 1 \Rightarrow P \geq 2$$ 🤔

- Just after entry, all firms earn zero profits (equal quantities)
- So 😱and 🤔$\Rightarrow Q_n^{SR}(P) \geq n(2/2) = n$ and $P_{n-1}^{SR}(P) \leq 2\frac{n}{n-1}$
- The long run supply curve is therefore a **sawtooth curve**



The supply curve is not the cheapest way to produce any given quantity. Indeed, two firms produce $q = \sqrt{2}$ as cheaply as one:
$1 + (\sqrt{2})^2 = 2[1 + (\sqrt{2}/2)^2]$

Example — Supply with Heterogeneous Firms

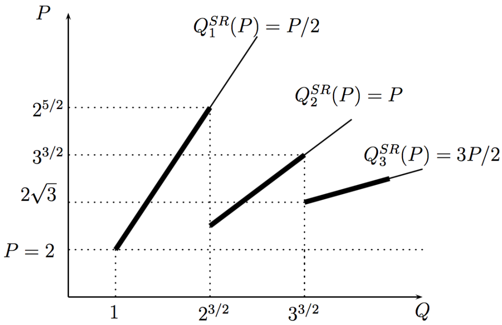
- Firm n has the cost function $C_n(q) = n + q^2$, for $n = 1, 2, \ldots$.
- So supply is unchanged at 😱: $Q_n^{SR}(P) = nq = nP/2$.
- For the long run, since the fixed cost is escapable (variable), each firm now has different average costs. For firm n, we have

$$MC = P \geq C(q_n)/n = \frac{n}{q} + q \Rightarrow 2q \geq \frac{n}{q} + q \Rightarrow q \geq \sqrt{n} \Rightarrow P \geq 2\sqrt{n}$$ 😬

$\Rightarrow$ the least quantity is $Q_n^{SR}(2\sqrt{n}) = n(2\sqrt{n})/2 = n\sqrt{n}$ 😳

- Only the marginal firm now earns zero profits.
- Inframarginal firms earn positive profits
  - $=$ returns to a fixed factor, like a location or other fixed asset.
  - If this asset is properly priced, the accounting profits disappear.

Sawtooth Long Run Supply with Heterogeneous Firms



The supply curve now rises due to cost convexity and heterogeneity

- Repeatedly applying the supply curve quantity ranges , and sawtooth prices rising from $2\sqrt{n}$ ( ) to $2\sqrt{n} \cdot 2/(n-1)$ ( )
- $n = 1$: $P_S(Q) = 2Q$ on $[1, 2\sqrt{2}]$ from $P = 2$ to $P = 4\sqrt{2}$.
- $n = 2$: $P_S(Q) = Q$ on $[2\sqrt{2}, 3\sqrt{3}]$ from $P = 2\sqrt{2}$ to $P = 3\sqrt{3}$
- $n = 3$: $P_S(Q) = 2Q/3$ on $[3\sqrt{3}, 4\sqrt{4}]$ from $P = 2\sqrt{3}$ to ...