An Economic Theory Masterclass

Part II: The Supply and Demand Paradigm

(An Intro to Chicago Price Theory)

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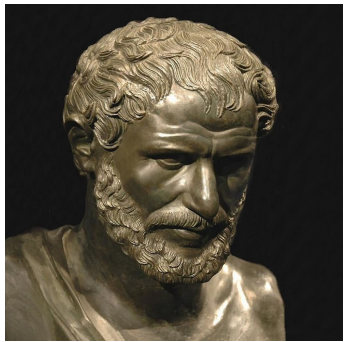
The Supply and Demand Paradigm

- competitive price-taking environment by all parties
- usually upward sloping supply curve
  - With returns to scale, supply price could fall with quantity (e.g. Amazon)
- usually downward sloping demand curve
  - very negative income effects $\Rightarrow$ demand rises in price
  - addictive behavior $\Rightarrow$ WTP rises with quantity (oh no, drugs)
- Each curve reflects both extensive and intensive margins -
  - extensive margins: entry/exit or double auction trade decisions:
    - WTP (willingness to pay) and WTA (willingness to accept)
  - intensive margins: people buying or less (double auction omitted this margin)
- 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
- Supply and demand are not just static notions
- Units are per week, or per day, etc.
- Life is all about dynamics: Heraclitus — Panta Rhei
  - "All entities move and nothing remains still"
- "No man ever steps in the same river twice"

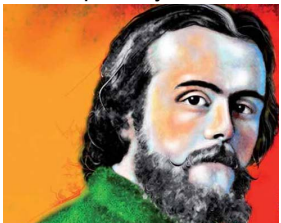


Stability — Does Competitive Equilibrium Happen?

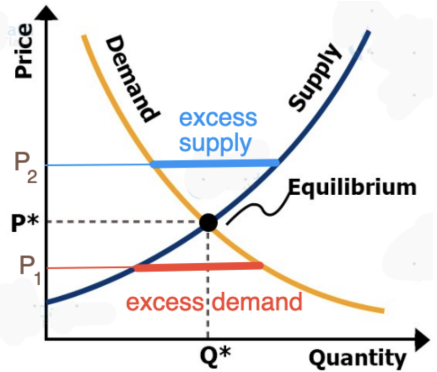
- If the world is changing, should market equilibrium arise?
- We explore the adjustment *tatonnement process* ("groping")
- Walrasian price stability *(Elements of Pure Economics*, 1874)
  - price adjustment process of fictional double auctioneer
  - If *net demand* is positive at some price, then the price rises
  - If net demand is negative, then the price decreases

  $\Rightarrow$ change in the price shares the sign of $Q_D - Q_S$.
- Marshallian quantity stability
  - Assume sellers are producers who adjust production after seeing demands
  - If demand price exceeds supply price at some quantity, quantity rises

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

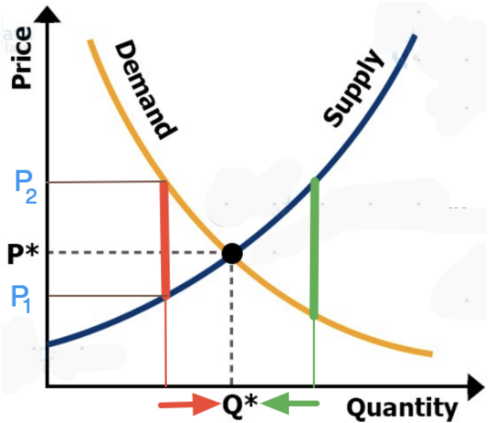


Walrasian Stability



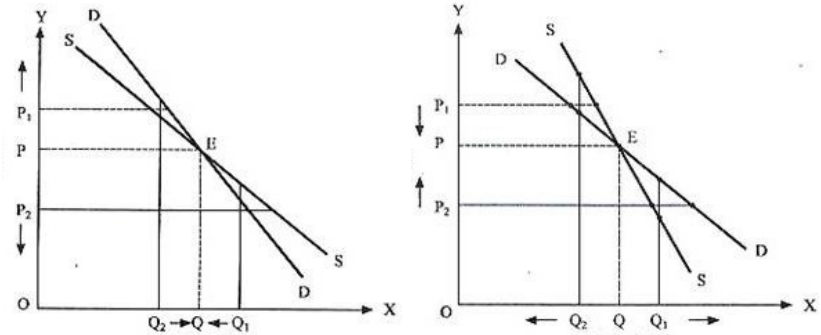
- Dynamic stories (sometimes explored in advanced theory):
  - random search by people who engage in pairwise bargaining over prices
  - forward-looking optimization about willingness to accept
  - During the adjustment, the short side of the market determines quantity.
    - Demanders won't demand more than they want at that price.
    - Suppliers won't sell more than they are willing at that price.

Marshallian Stability



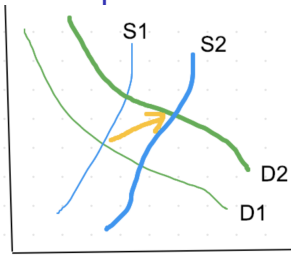
- Marshallian and Walrasian stability both work for standard downward-sloping demand and upward-sloping supply

Stability: Downward-sloping Demand and Supply



- demand steeper than supply $\Rightarrow$ Walrasian unstable and Marshallian stable
- supply steeper than demand $\Rightarrow$ Walrasian stable and Marshallian unstable

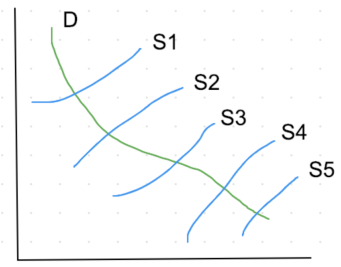
Comparative Statics aka Comparison of Steady States Analysis



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



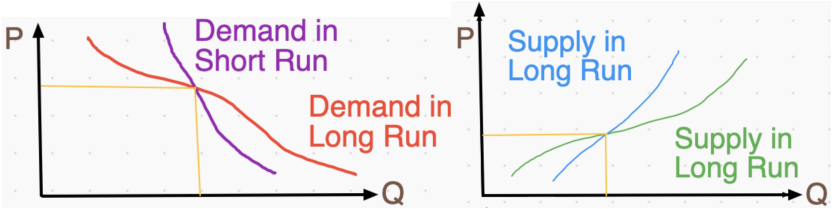
Elasticities Review

- For small price changes:

$$\varepsilon = \frac{dQ}{dP}\frac{P}{Q} = \frac{d\log Q}{d\log P} \approx \frac{\%change\ quantity}{\%changeprice}$$

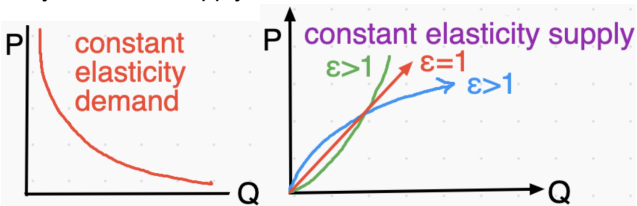
- Elasticity is a ratio of proportionate changes $\Rightarrow$ unit-free!
- More elastic supply or demand $\Rightarrow$ quantity changes more if price falls
- The long run has fewer constraints than the short run
- Le Chatelier's Principle: *The absolute change of any choice variable is weakly higher in the longrun than shortrun.* (see Varian; follows from profit function)

  $\Rightarrow$ |long run elasticity| > |short run elasticity|



Elasticities Review

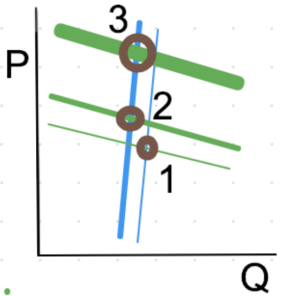
- Q1: Characterize constant elasticity rising supply curves.
  Answer: Upward sloping supply curves, linear if $\varepsilon = 1$
- Q2: Characterize constant elasticity falling demand curves.
- Answer: Hyperbolic downward sloping curves: $P \propto Q^{1/\varepsilon}$, for $\varepsilon < 0$
  - Proof: Rewrite $Q'(P)P/Q = \varepsilon$ as $dQ/Q = \varepsilon dP/P$
  - Integrating yields $\Rightarrow \log Q = \varepsilon \log P + \log K \Rightarrow Q = KP^{\varepsilon}$.
  - Finally, $\varepsilon > 0$ for supply curve and $\varepsilon < 0$ for demand curve



- When $|\varepsilon| > 1$, we call the supply or demand elastic
- PS Demand elasticity is spoken of in absolute terms!
- PPS Behavioral SIR model: the demand for vigilance is constant elasiticity

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



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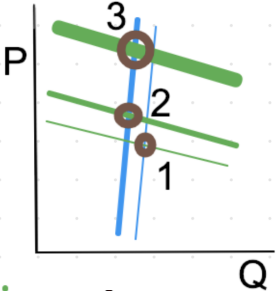

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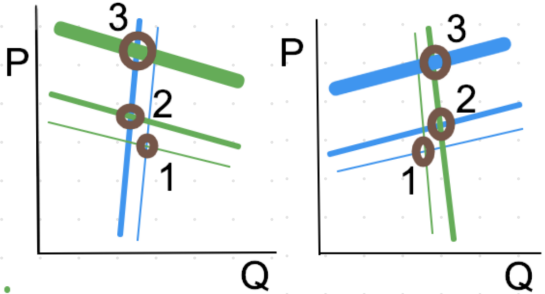

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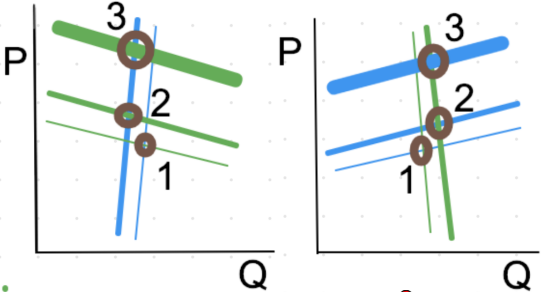

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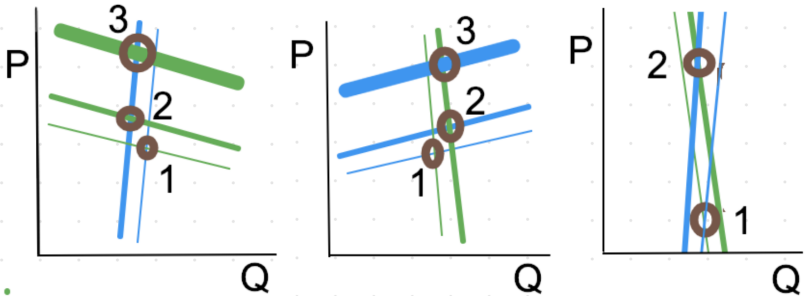

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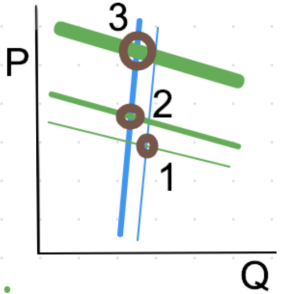

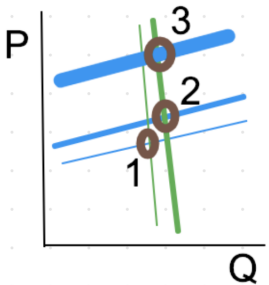

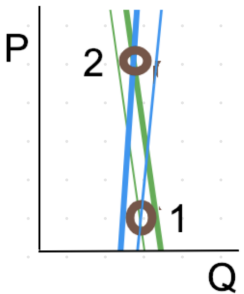

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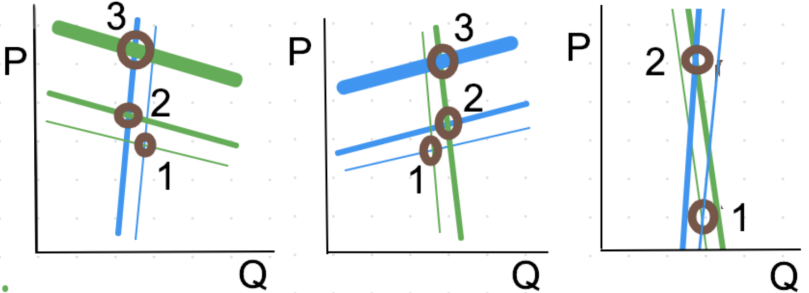


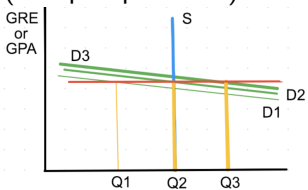
- Lesson 1: Small fundamentals shifts cause large proportionate price changes iff both supply and demand are highly inelastic.
- Lesson 2: Inelastic supply or demand $\Rightarrow$ low quantity volatility

Price and 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
- Price volatility is greater in the short run
- Quantity volatility is greater in the long run

Large Quantity Volatility in an Implicit Market

- College admissions is an "implicit market", where the "price" is the admission bar (like risk of death is an implicit price in the pandemic in the BSIR)
- Chade, Lewis, and Smith (2014), "Student Portfolios and the College Admissions Problem" do not claim the conjectured demand curves (an open problem!)



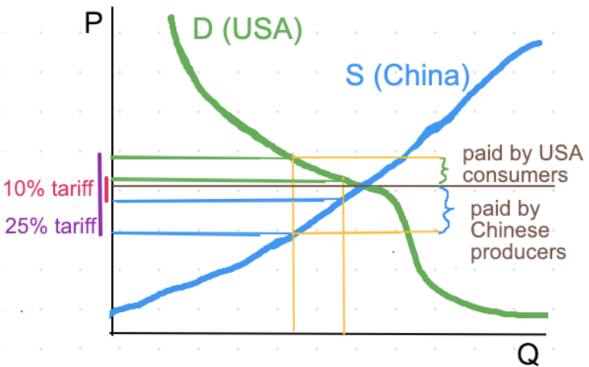
- Without waitlisting, as in PhD admissions, acceptance bar mistakes can lead to massive changes in acceptance rates.
- 2017: UC-Irvine unadmitted 499 students

Shared Incidence or Tax or Tariff

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

$\Rightarrow$ 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
- Fact: The more elastic is demand, the less of the tariff buyers pay.
- Fact: The more elastic is supply, the less of the tariff suppliers pay.

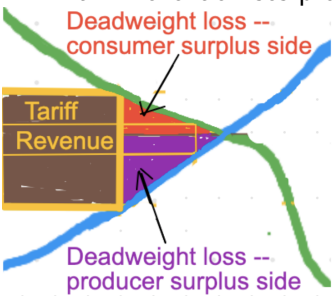


Deadweight Loss of Tax

- 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

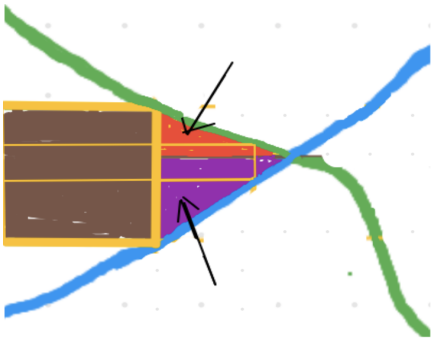
- Tariff revenue rises proportionately less than the tariff rise



←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?)

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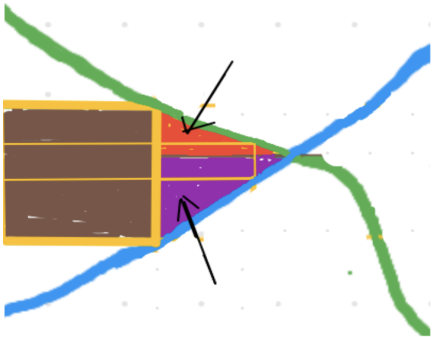
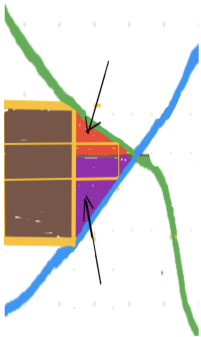




(less elastic S and D)
(shortrun?)

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 $\Rightarrow$ down-shift in demand
- VAT is paid by suppliers (hidden in price) $\Rightarrow$ 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

- Double auctions: No effect of small tax!
- Tax 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)

Who pays the tax is irrelevant for tax incidence! It is always true that the share of a small tax τ paid by demand is $\frac{\eta}{\eta-\varepsilon} \leq 1$, and by supply is $\frac{-\varepsilon}{\eta-\varepsilon} \leq 1$.

- *Proof*: Impose a small excise tax $\boxed{\tau \equiv dP_D - dP_S > 0}$
- $dQ \approx \varepsilon dP_D(Q/P)$ and $dQ \approx \eta dP_S(Q/P) \quad \Rightarrow \quad \varepsilon dP_D \approx \eta dP_S$

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

Deadweight Loss for Small Taxes

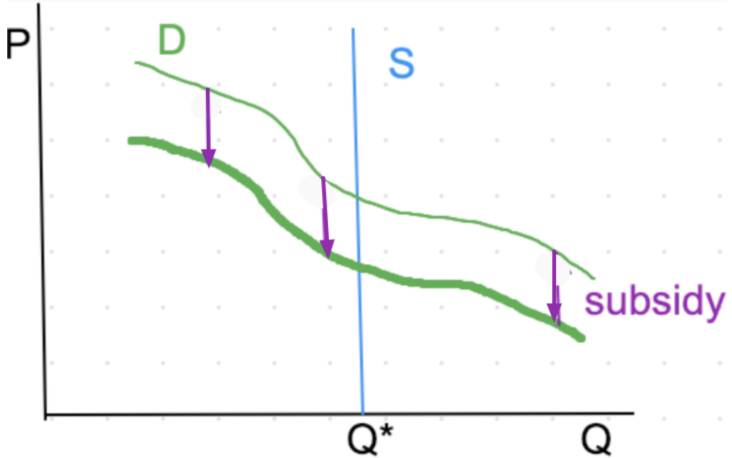
- Since $\varepsilon = (dQ_D/dP_D)(P_D/Q_D)$, the quantity changes by

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

- Deadweight loss: Lost gains from trade = lost CS + PS
- Hence, the deadweight loss is the area of the standard triangle:

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

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

Optimal Taxes: the Ramsey Inverse Elasticity Rule

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

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

  $\Rightarrow$ never tax an elastically demanded good
- Optimal taxes seek to minimize deadweight losses for any given revenue
- This paper predated the 1950 invention of Kuhn Tucker analysis!!
- Ramsey (1927): Minimize the social cost of raising revenue R

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

  where $V(p, I)$ is the indirect utility function for prices p and wages w
- **Ramsey inverse elasticity rule**: "taxes should be proportional to the sum of the reciprocals of its supply and demand elasticities"
- $\Rightarrow$ governments shouldn't tax elastically demanded goods or supplied goods

Optimal Taxation Theory Explains Real World Taxes

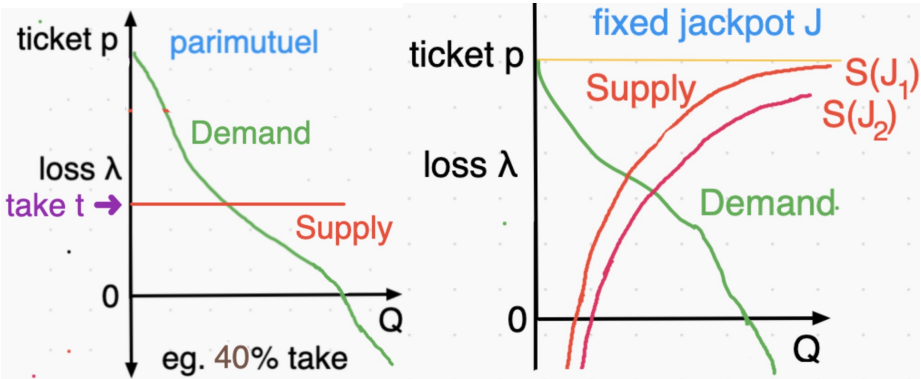
- Ramsey's basic insight is intuitively understood by governments
- They know to tax inelastically supplied resources:
  - Oil taxes, mineral taxes
  - existence tax: poll tax (head tax) in Britain (fertility impact?)
  - wealth taxes are usually real estate, or at death taxes
  - millionaire tax? billionaire 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
- Funny example of a tax fail:
  - 2008, Maryland "millionaire's tax" of 6.25% tax rate on income $>$ \$1 million
  - 30% drop in millionaire's taxpayers and 22% drop in declared income.

  $\Rightarrow$ income taxes from this group fell by \$257 million
  - Tax ended in 2010

Application of Supply and Demand to Rollover Lotteries

- Why do people gamble? Risk neutral Quasi-linear story: People gamble if the expected utility of winnings plus the thrill of playing exceeds the ticket price p.
- Quantity Q tickets sold for a drawing
- We treat this as an implicit market where the expected losses λ from tickets as the "net price" of thrill of the lotto experience.
- Parimutuel pays out a fixed percentage of bets: λ is constant
  - Odds are fixed, prize is variable
- Classic lotto: fixed jackpot J (giant panda or \$1M): $\lambda = p - J/Q$
  - Prize is fixed, odds are variable
- In a Genoese lottery, people pick their own numbers: If no one wins, the prize rolls over; if many win, the prize is shared.
- Powerball and Megamillions are Genoese lottos, with a fixed first place prize (jackpot from past lottos) plus lesser classic lottos
  - Odds are $259M : 1$ for Megamillions and $292M : 1$ for Powerball.
- Demand curve is the locus of lotto losses vs thrill, could be negative

Supply Curve of Lotto Losses, as the Jackpot Rises



- parimutuel lottery revenue $\lambda D(\lambda)$ rises in take λ if demand is inelastic
- Supply curves shift down as the jackpot rises, negative for large J.
- Rollovers increase the jackpot, and shift the supply curve — identifying 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

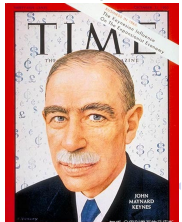
- A cost is **escapable** if can be avoided.
- Otherwise, it is inescapable or "sunk".
- Since such costs are unavoidable, they cannot possibly affect behavior, and should be ignored in all optimizations

= essence of dynamic programming

- 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 $\Leftrightarrow$ intensive margins
- Average costs $\Leftrightarrow$ extensive margins

Short, Medium, Long Runs

- 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" (short run theory)
- **"Medium run"**
  - more decision margins available, and so more costs escapable, than in the short run, and fewer than in the long run.
- Time Magazine Cover 12/31/1965
- "We are all Keynesians now." (Milton Friedman)



Long Run Supply

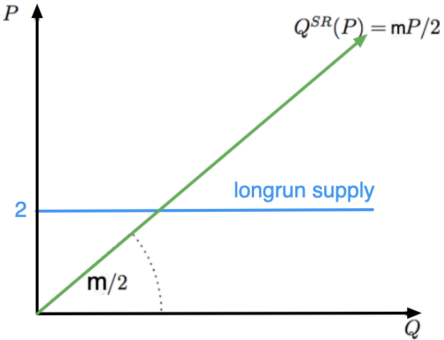
- **Industry supply curve**
  - price-quantity locus (P, Q), such that, the allowable firms — i.e., the existing firms in the short run, or all potential firms in the long run — profitably produce Q taking price P as given
  - Note: price-taking behavior is incredible with few firms
- Cost functions $C(q) = 1 + q^2$ (fixed cost 1 & variable cost q^2)
- Optimal production: $P = C'(q) = 2q \Rightarrow$ output $q = P/2$.
- 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's Principle)
- The least price needed for production is 2, since:

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

- Consequently, the long run inverse supply curve is $P = 2$.

Example of Supply with Homogeneous Firms

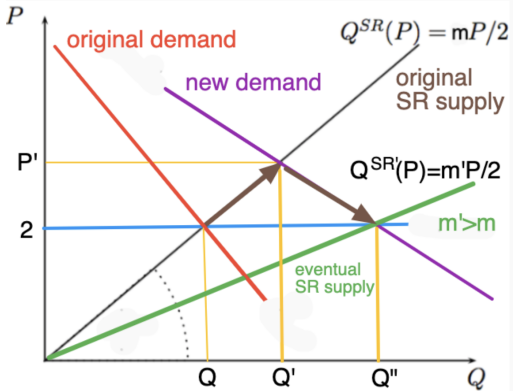
- Short run supply with mass m of firms: $Q_m^{SR}(P) = mq = mP/2$ (😱)



- Just after entry, all firms earn zero profits (equal quantities)
- The short run supply curve rises simply due to cost convexity.
- All short run profits owe to cost convexity (diminishing returns)
- This intensive margin effect — firms sell more with a higher price — was absent with double auctions

Supply and Demand Shifts with Homogeneous Firms

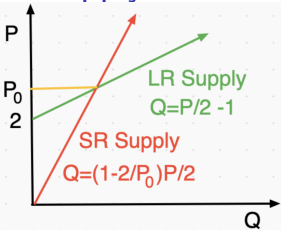
- Assume a demand shock, from an old to a new demand curve.
- In the short run, every firm rides up its supply curve
  - The price increases to $P' > 2$ and the quantity to $Q' = Q^{SR}(P') > Q$
  - temporary positive profits during adjustment are called quasi-rents
- Over time, entry occurs; the mass of firms rises from m to $m' > m$, during which time, the price falls to 2, while quantity rises to $Q'' > Q'$



Example — Supply with Heterogeneous Firms

- Firm with cost index x has costs $C_x(q) = 1 + x^2 q^2$
- Assume the index x has a unit mass density on $[1, \infty)$
- Higher index firms produce less output q_x when positive
  - Supply of firm x is $MC_x = P \Rightarrow$ linear supply $\boxed{q_x(P) = P/(2x^2)}$ (😬)
- Short run: No one shuts down:
  $AC_x(q) = x^2 q_x < 2x^2 q_x = MC_x(q) = P$
- Long run
  - The fixed cost 1 is escapable, and included in costs
  - $\Rightarrow$ $AC_x(q) = 1/q_x + x^2 q_x = 2x^2/P + P/2 \leq P$ for all firms $x \leq P^2/4$
  - The marginal firm $\boxed{x(P) = P/2}$ earns zero profits
  - $\Rightarrow$ U-shaped average costs
  - $\Rightarrow$ minimum efficient scale: $x^2 - 1/q_x^2 = 0$, or $q_x^* = 1/x < 1$.
  - $\Rightarrow$ The minimum average cost is $2x \geq 2$
  - The price must pay for the minimum average costs, and so exceed 2.

Long Run vs. Short Run Supply with Heterogeneous Firms



- Long run supply is sum of all output by inframarginal firms $x \leq x(P)$:

$$Q_S^{LR}(P) = \int_1^{x(P)} q_x(P)dx = \int_1^{P/2} P/(2x^2)dx = [P/2][-x^{-1}]\Big|_1^{P/2} = \tfrac{1}{2}P - 1$$

- The supply curve now rises due to cost convexity and heterogeneity
- Market supply is more elastic than firm supply
- For a fixed price P_0, we can define the induced short run supply curve:

$$Q_S^{SR}(P|P_0) = \int_1^{x(P_0)} P/(2x^2)dx = [P/2][-x^{-1}]\Big|_1^{x(P_0)} = (P/2)[1-2/P_0]$$

Concluding Thoughts on Extensive and Intensive Margins

- 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.
- As economics expands, are new economists as good as the old ones?
- iOS / Apple / Windows ecosystems etc. are enclosed economies where these dynamics play out
- Demand with Heterogeneous Consumers: As a market expands, the new consumers like the good less (eg. lotteries) but may also consume less of it