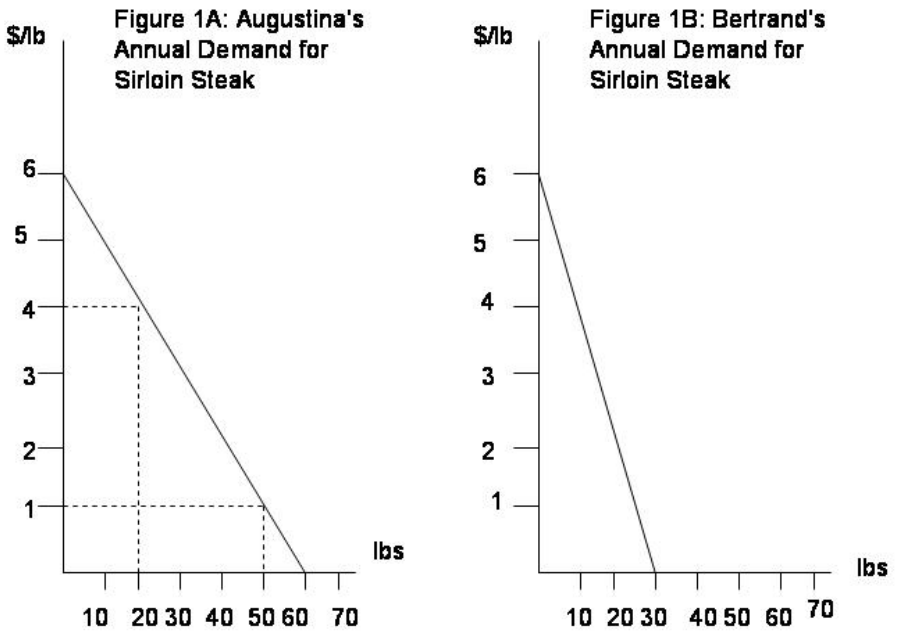
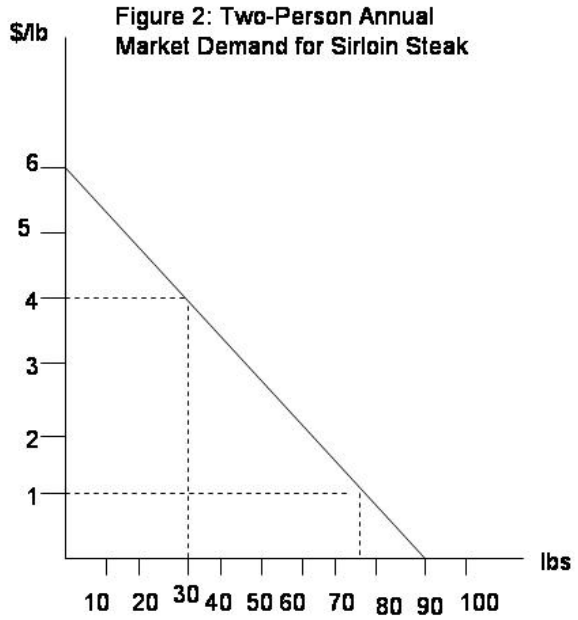
Welfare Economics

I) Demand Curves
   A) Q: What is a demand curve?
   B) There are two primary types of demand curves – individual and aggregate
   C) Individual demand curves
      1) These curves provide a diagram of the number of units of a particular good that a specified individual would purchase during a specified period of time as a function of the price of that good.
      2) For example, how many pounds of sirloin steak would you purchase each year if the price is at $5.00 per pound? Would you buy more or less if the price were $4.00 per pound? Most people would buy more. Some people, e.g., vegetarians, would not change the amount they purchase as the price changed.
      3) We can depict the annual demand of two different individuals for sirloin steak by graphing the amounts they purchase as a function of price (Figure 1A and 1B).




      4) Note several things:
         a) Both Auggie and Bertie reduce the amount of steak they buy when the price rises.
         b) The most steak Auggie (Bertie) will ever consume is 60 (30) pounds per year, and then only when the price drops to zero. Both of them will stop consuming steak when the price rises above $6/lb.




c) The way to interpret Figure 1a is that when the price of sirloin is $2/lb, Auggie will buy 40 pounds per year. When the price is $5/lb, she will only purchase 10 pounds per year.

d) These graphs represent the mathematical relation between price and demand for a good - sirloin. We can derive a mathematical formula for this relation. Use p to denote the price of sirloin, $Q_a$ to denote the amount the amount of sirloin Auggie buys and $Q_b$ to denote the amount that Bertie buys.

e) Each graph is a representation of a demand function:
   i) Auggie's *demand function*, Figure 1a: $Q_a = 60 - 10P$
   ii) Bertie's demand function, Figure 1b: $Q_b = 30 - 5P$

f) Now here is the tricky part:
   i) Notice that a demand function expresses the quantity demanded as a function of the price.
   ii) Look at the graphs of the demand. What is the dependant variable (vertical axis)? Price. What is the independent variable? Quantity.
   iii) So, the "demand" graphs actually depict the *inverse demand function*.
   iv) What is the inverse demand for Auggie and Bertie?
      (A) Auggie: $P = 6 - 1/10\ Q_a$
      (B) Bertie: $P = 6 - 1/5\ Q_a$

D) Market demand curves
   1) Market demand curves are simply the aggregation of all individual demand curves
   2) Horizontal summation of individual demand curves gives the market demand
      a) See Figure 2
      b) This is the sum of Auggie and Bertie's individual demands
      c) See the tutorial on aggregation of supply and demand curves on the class website.
   3) Notice that the demand curve, which plots willingness to pay, can also be interpreted as a marginal benefit (MB) curve.

4) We generally assume that demand curves are downward sloping.
   a) Q: What does that imply?
   b) The standard demand curve demonstrates *diminishing marginal benefits*
5) Consumer Surplus

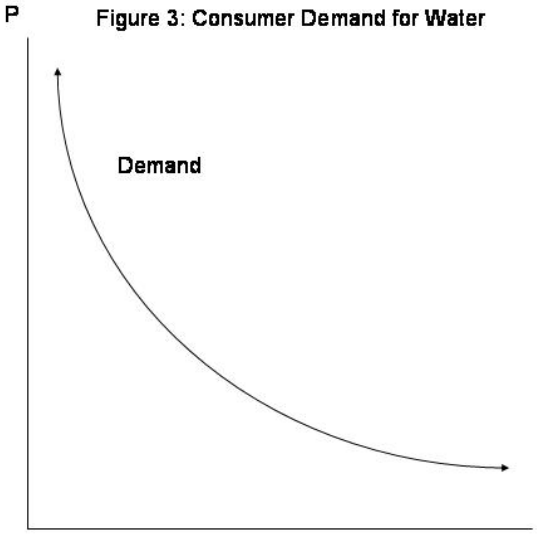


Figure 3: Consumer Demand for Water

   a) Consider the case of water consumption
      i) As an individual…
         (A) What do we know about the first gallon of water you consume each month? Is it highly valued?
         (B) How much do you pay for that water?
         (C) Are you paying less than its value to you? Yes, considerably so.
      ii) Similarly for market demand curve – not everyone is paying as much as they are willing to pay
   b) *Consumer surplus* – gross benefits less the amount paid (see Figure 4).

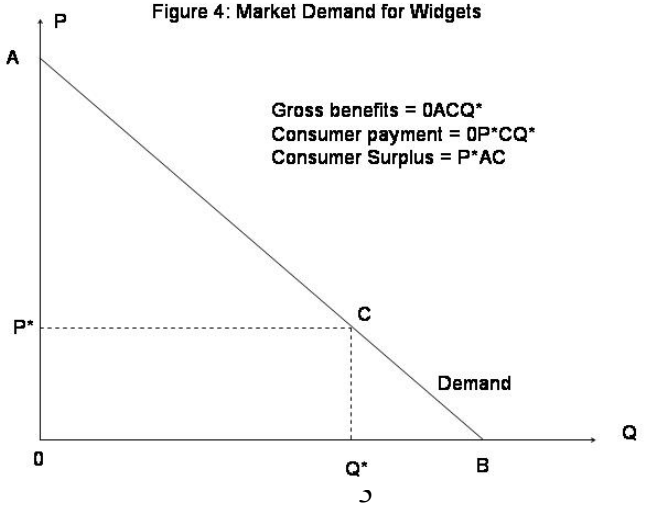


Figure 4: Market Demand for Widgets

i) *Gross benefits*

(A) In Figure 4 the *gross benefits* of consuming Q* units are simply the sum of the benefit of consuming the first unit plus the benefit of consuming the second unit and so on up to the Q* units. \

(B) Consumers are willing to pay A $/unit for the first unit. They are willing to pay a bit less for the next unit and a bit less for the one after that. Consumers are only willing to pay P* dollars per unit for the last of the Q* units. At each level, they are willing to pay an amount equal to their marginal benefits, so the sum of their willingness to pay (the area under the demand curve from 0 to Q*) is equal to their total benefits.

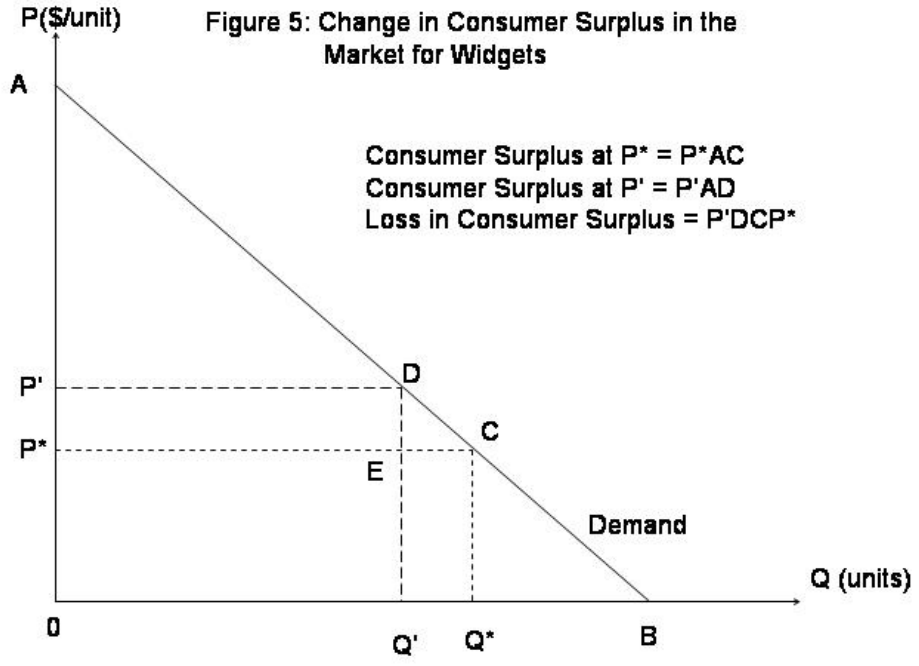
(C) In Figure 4 the gross benefits are the area ACQ*0

ii) The *consumer payment* is simply the price per unit times the number of units purchased – In Figure 4 this is (P*)(Q*) which is equal to the area P*CQ*0.

c) The *consumer surplus*, then, is the difference between gross benefits and price paid: ACQ*0 - P*CQ*0 = AP*C

d) Changes in consumer surplus are a good approximation of society's costs or benefits associated with projects that affect markets

i) In Figure 5, when the price rises from P* to P' (a change of ΔP) the consumer surplus declines from P*AC to P'AD (a change of ΔCS).

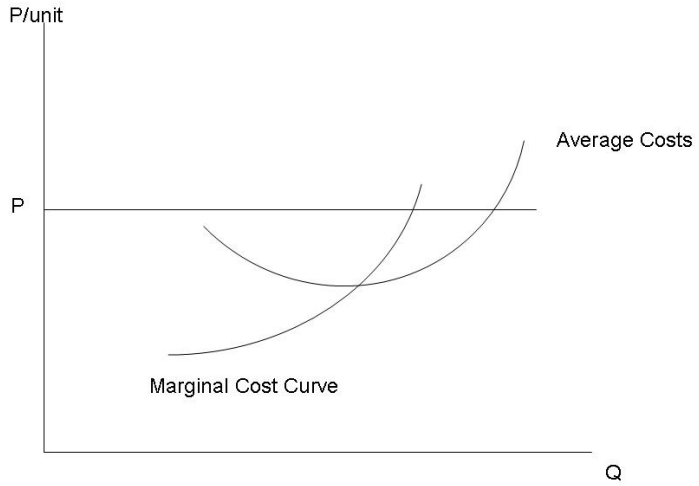



ii) The change (loss) in consumer surplus is P'DCP*

II) Market Supply Curve

A) Individual firms' supply curve

Figure 6: Individual Firm Supply is Derived from the Marginal Cost Curve

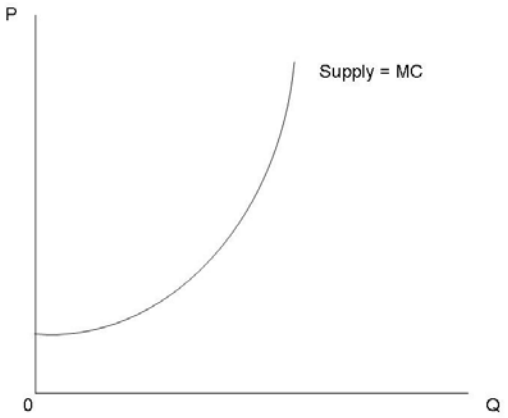



1) Shows upward sloping *marginal cost curve*
   a) In the short run at least one factor of production – e.g., capital is fixed – so eventually get diminishing returns leading to increasing marginal costs
   b) Must cover at least average variable cost – otherwise firm would have to shut down.
   c) The firms' supply curve is the part of the MC curve above the AVC
   d) We are assuming that the firm is paying for all resources it uses – including a *normal return* to capital
   e) Total variable cost is the area under the MC curve – must get at least that much to pay for variable costs
   f) Firm maximizes net income at price P* by producing at the level of Q that corresponds to that price on the marginal cost curve.

B) Market supply

1) Market supply curve

Figure 7: Market Demand Curve is the Horizontal Sum of Individual Supply Curves

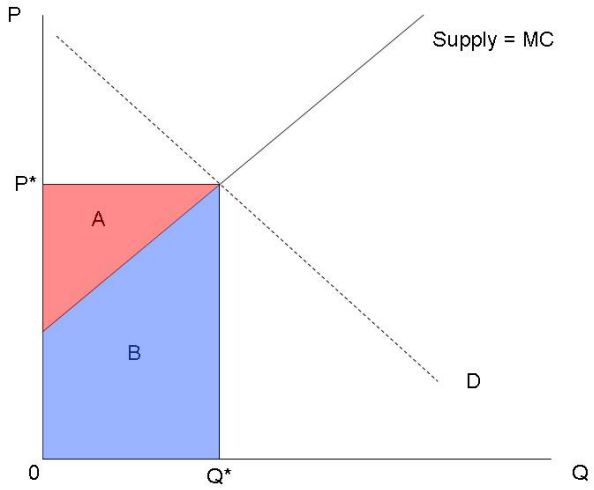


2) Just like market demand curve is made up of demand of all consumers – market supply curve is made up of individual supply schedules of all producers – horizontal summation.
3) For mechanics of summation see the tutorial on aggregation of supply and demand curves on the class website.

C) Producer surplus

1) The difference between revenues from selling and the cost of producing is called *producer surplus*

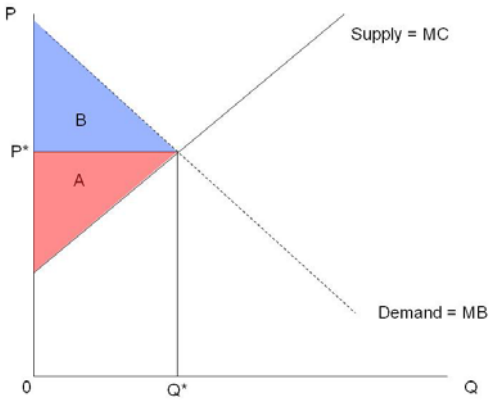
Figure 8: The Producer Surplus is the Difference between Payments Received and Costs of Production




2) The cost of producing Q* units is the area under the MC curve, out to Q*, i.e., B, the blue area
3) The total revenue is price x quantity, i.e., the area A+B
4) So producer surplus is the difference between revenue and cost of production: (A+B) – B = A

III) Social surplus

Figure 9: Social Surplus is the Sum of Consumer Surplus and Producer Surplus




A) What happens when you lay the demand and supply curves over each other?

B) Sum of consumer and producer surplus is *social surplus* (Figure 9)

IV) **Government's Policy Tools for Intervention in Markets**

A) Government has several policy tools to address market failures. Each one involves altering the markets for goods or services in important ways.

B) These tools include:

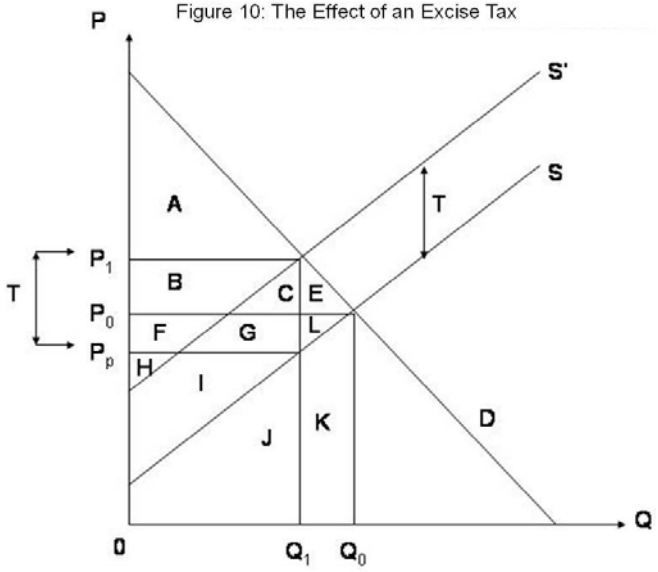
1) Taxes
2) Subsidies
3) Price ceilings
4) Price floors
5) Production quotas
6) Government purchases
7) Regulations

C) To review your V517 lessons, we will work through the policy instruments one at a time.

**D) Taxes**

1) Consider the case of an excise tax of T ($/unit) placed on a commodity as pictured in Figure 10.

Figure 10: The Effect of an Excise Tax




2) Before the government intervenes in the market, the equilibrium price and quantity are $P_0$ and $Q_0$. When the government intervenes by placing a tax of T $/unit, the supply curve essentially shifts up by an amount T to the new supply curve S' , i.e., the marginal cost of supplying the good at any quantity, Q, has risen by an amount T.

3) The intersection between the demand curve and the new supply curve has shifted to $P_1$ and $Q_1$. So one effect of the tax is to decrease the quantity consumers buy and to increase the price they pay per unit.

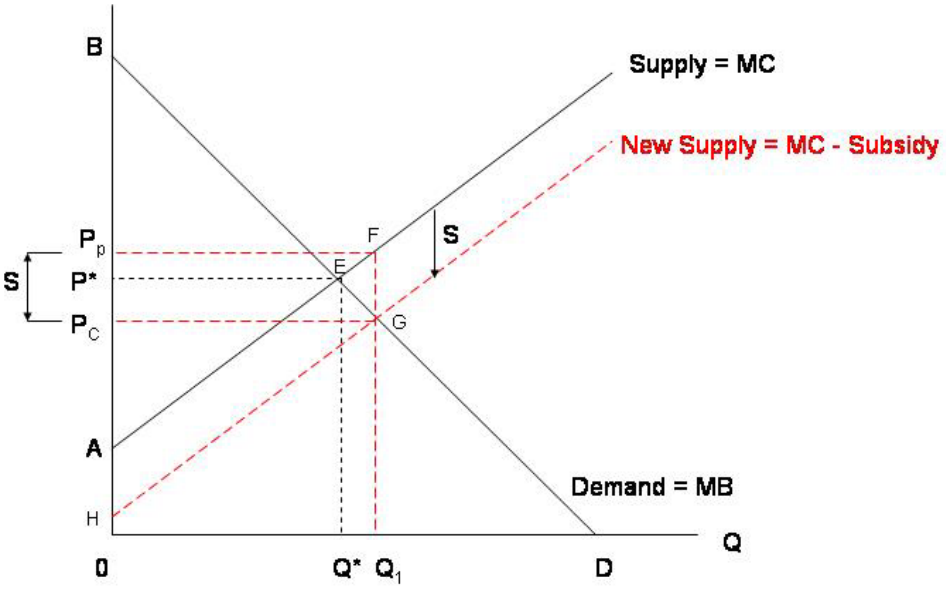
4) The new price to consumers is $P_1$($/unit). The government collects T $/unit. So the net amount that producers receive is $P_p = P_1 - T$ ($/unit)

5) How does this affect the consumer surplus? Before the tax, consumer surplus was A+B+C+E. After the tax the consumer surplus is just A.
6) How does this effect producer surplus? Before the tax producer surplus was F+G+H+I+L. After the tax it is just H+I.
7) $\Delta CS = -(B+C+E)$ and $\Delta PS = -(F+G+L)$ Where did all this lost surplus go? The government collected B+C+F+G. But E+L was simply lost because the quantity shifted from its optimal level of Q* down to $Q_1$. We call this area (E+L) *deadweight loss*.

**E) Subsidies**

1) There are many ways for the government to provide *subsidies* – through tax credits, deductions, direct payments, in-kind awards or goods or services.
2) The effect of all is very similar although there are nuances attached to each.
3) In this class we will concentrate on a subsidy in which the government either
   a) Pays manufacturers a set $/unit, S, for selling a particular good, or
   b) Pays consumers a set $/unit, S, for buying a particular good.
   c) The analysis is essentially the same regardless of who receives the subsidy
4) The analysis of these subsidies is very similar to the analysis of excise taxes – think of it as a negative tax.
5) Consider a case where the government is going to subsidize the production of flour by an amount S $/unit. Let's ask what happens to producer and consumer surplus.

**Figure 11: A Subsidy Paid to the Producers**




6) The case where the government subsidizes producers (Figure 11). Notice that we are using a slightly different notation in this graph. You need to learn to work with all the different types of notation (e.g., Figures 9, 10 and 11).
   a) Before the subsidy, the equilibrium price and quantity are P* and Q* determined by the intersection of the supply and demand curves at E.
   b) Notice that when the government pays a subsidy of S $/unit to the producers, the MC of production is reduced by the amount S $/unit, which

in turn lowers the supply curve. The intersection of the new supply curve with the demand curve is now at G, so the new price that the new price that consumers are paying has dropped to $P_C$. At this lower price, they purchase more units, moving from Q* to $Q_1$.

c) Prior to the subsidy, the consumer surplus was BEP*. After the subsidy it has increased to $BGP_C$. This is an increase of $P^*EGP_C$.

d) Prior to the subsidy the producer surplus was AEP*. After the subsidy the consumer surplus is $HGP_C$. By geometry, this area is equivalent to $AFP_p$. This represents an increase of $P^*EFP_p$.

e) So between the gains to producers and consumers there is a total increase in surplus of $P_cGEFP_p$. Where did this come from? The government paid for it through the subsidy.

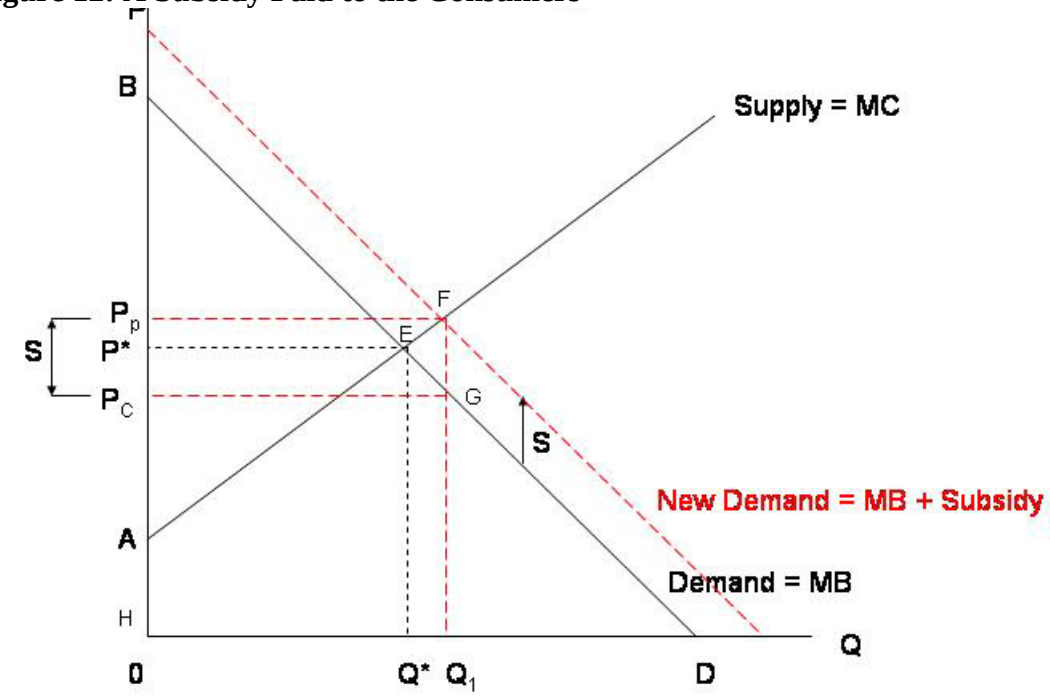
   i) What is the size of the government payment? $(S)(Q_1)$ or $P_pFGP_c$.

   ii) Notice that the government payment exceeds the gain in producer and consumer surplus by the amount EFG. This amount is also known as the *deadweight loss* associated with the subsidy.

7) Summary table

| | (1) Before Subsidy | (2) After Subsidy | Change = (2) – (1) |
|---|---|---|---|
| Consumers | CS = BEP* | CS = $BGP_C$ | + $P^*EGP_C$ |
| Producers | PS = AEP* | PS = $HGP_C$ | + $P^*EFP_p$ |
| Government | | - $P_pFGP_c$ | - $P_pFGP_c$ |
| Social Welfare | | | -EFG |

**Figure 12: A Subsidy Paid to the Consumers**



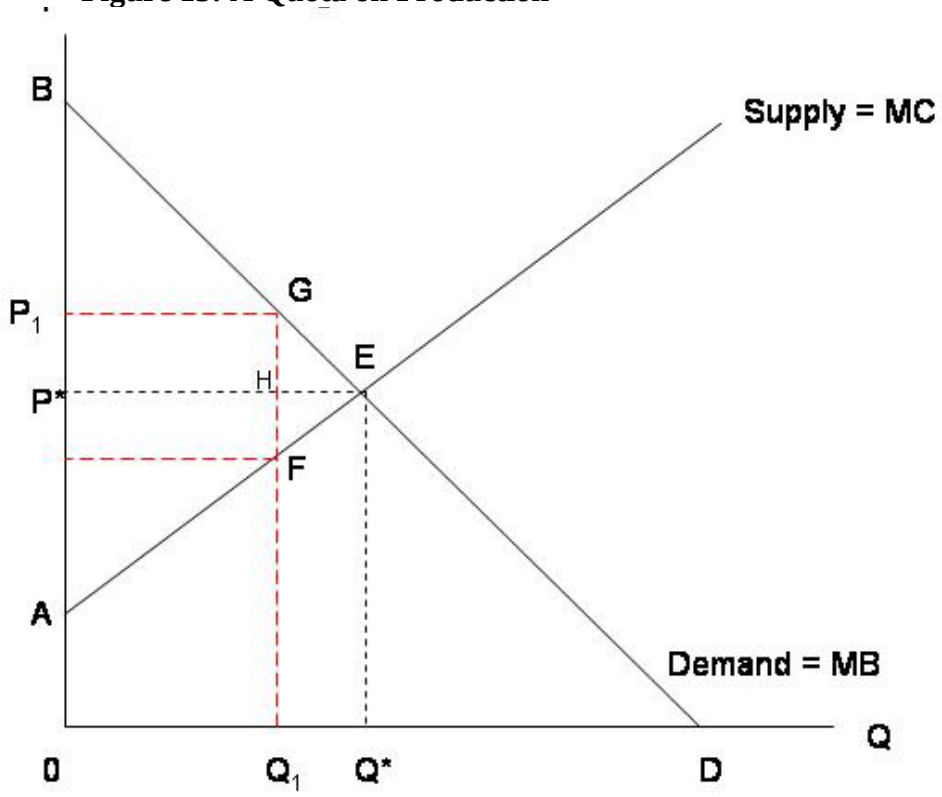

8) The case where the government subsidizes consumers (Figure 12)

a) Notice in this case that the subsidy raises the demand curve by an amount S $/unit. This is because now the consumer not only receives the MB of the good itself, but an additional benefit of S $/unit.
b) With this new demand curve the intersection with the supply curve shifts to F. At this point the quantity increases to $Q_1$ and the price that producers receive rises to $P_p$. Notice this is exactly the same configuration as in Figure 1. The analytics are also exactly the same, with the same gains in producer and consumer surplus and the same net loss in social welfare.

**F) Quotas**

1) The government can use *quotas* to restrict the production or import of a particular good. For example, the government "voluntary" quotas to restrict the import of Japanese cars in the early 1980s.

**Figure 13: A Quota on Production**




2) Consider the case shown in Figure 13. The government restricts sales of to a level Q1. At this lower quantity consumers are willing to pay $P_1$, so the price rises.
3) Consider the change in consumer surplus. Before the quota, CS = BEP*. After the quota it has declined to $BGP_1$. Consumer surplus has declined by $P_1GEP^*$.
4) What has happened to producer surplus? Before the quota the PS = AEP*. After it has changed to $AFGP_1$. (Remember that producer surplus is the difference between the revenue received by the producer, $(P_1{}^*Q_1) = P_1GQ_10$, and the cost of production, $AFQ_10$.) Producer surplus has changed by $P_1GHP^*$ - FHE. By examination (i.e., looking at the graph), this appears to be a positive number, but that isn't always the case.
5) So, with the introduction of a quota, consumer surplus will always decline and producer surplus may increase or decrease.
6) How does this effect social surplus?

| | Before Quota | After Quota | Change |
|---|---|---|---|
| Consumer surplus | BEP* | $BGP_1$ | $-P_1GEP^*$ |
| Producer surplus | AEP* | $AFGP_1$ | $P_1GHP^*$ - FHE |
| Social surplus | | | - GEF |

7) First, notice that consumers lost $P_1GEP^*$ in surplus. Of this $P_1GHP^*$ was lost because they had to pay a higher price for the $Q_1$ units they continued to consume. What happened to that $P_1GHP^*$? The producers received it, so it was not really lost to society, only transferred to the producers from the

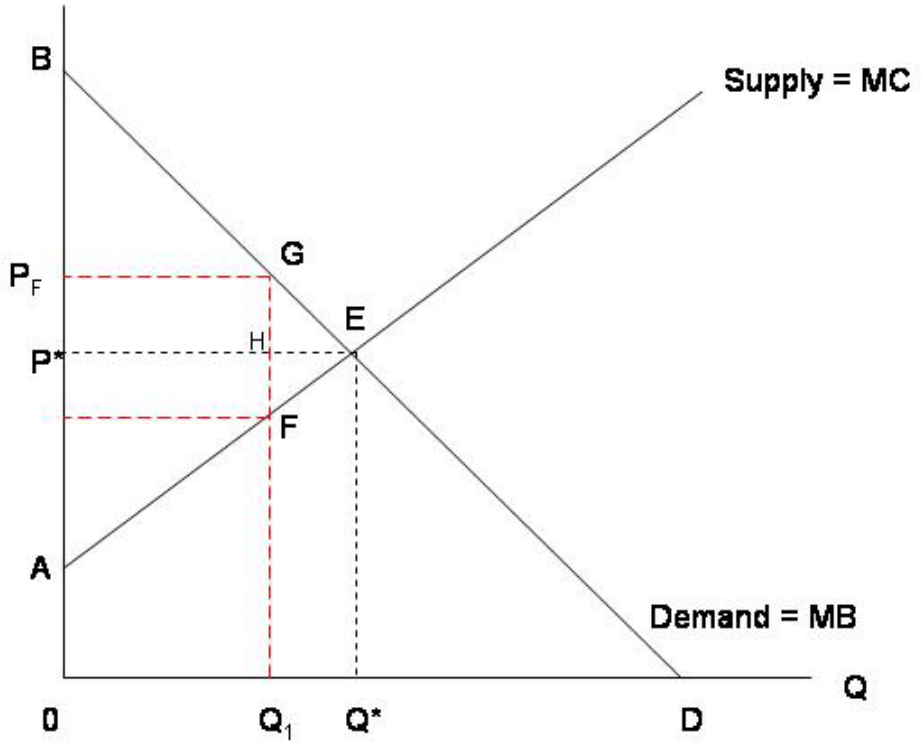
consumers. We call this a *transfer payment*. That means it was taken out of the pocket of one individual/group in society and given to another.

8) But there were also real changes in production decisions, so MC≠MB. This real loss in social surplus is measured as the area GEF, which signifies the *deadweight loss* associated with the quota.

**G) Price Floor**

1) The government is using a *price floor* when it declares that producers may not sell a good for less than a specified price, $P_F$. Note that a price floor is only really meaningful if $P_F > P^*$, the equilibrium price.

**Figure 14: A Price Floor**




2) Consider Figure 14, where the government has introduced a price floor of $P_F$. With this new higher price, the quantity demanded goes down to $Q_1$.

3) What is the change in consumer surplus? Before the quota, CS = BEP*. After the quota consumer surplus is $BGP_F$. Consumer surplus has declined by $P_FGEP^*$.

4) What has happened to producer surplus? Before the quota the PS = AEP*. After it has changed to $AFGP_F$ (Remember that producer surplus is the difference between the revenue received by the producer, $(P_F^*Q_1) = P_FQ_10$, and the cost of production, $AFQ_10$.) Producer surplus has changed by $P_FHP^*$ - FHE. By examination (i.e., looking at the graph), this appears to be a positive number, but that isn't always the case.

5) So, with the introduction of a quota, consumer surplus will always decline and producer surplus may increase or decrease.

6) How does this effect social surplus?

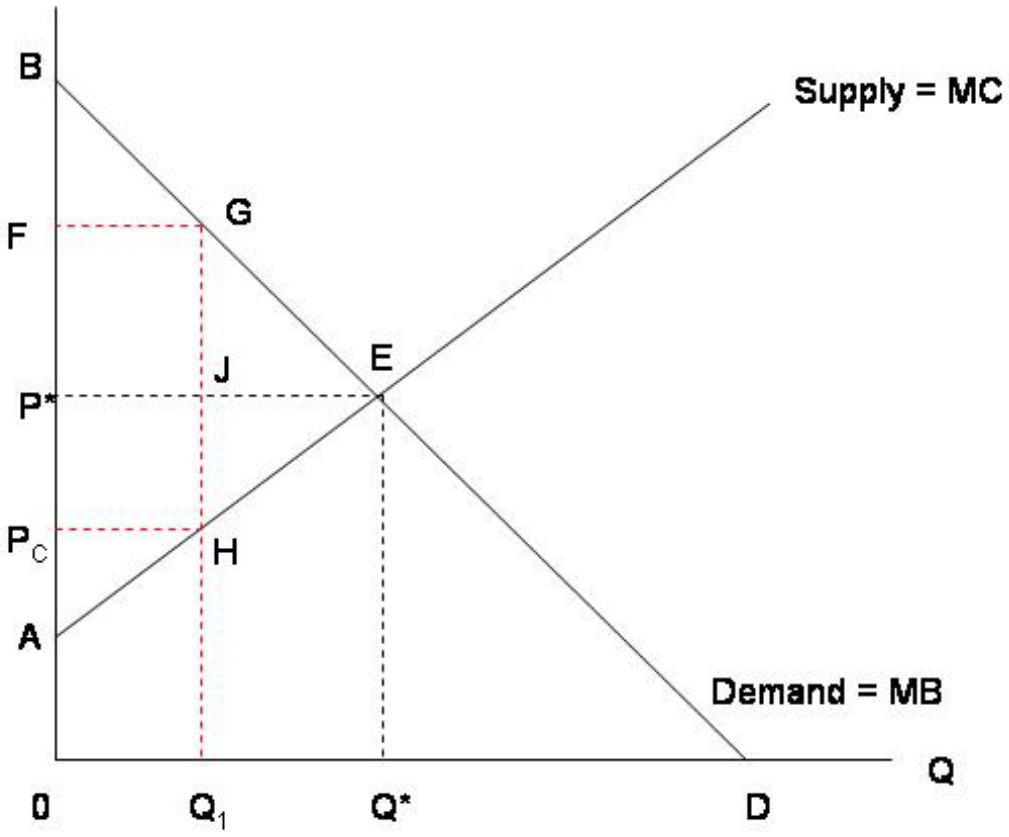
| | Before Quota | After Quota | Change |
|---|---|---|---|
| Consumer surplus | BEP* | $BGP_F$ | $-P_FEP^*$ |
| Producer surplus | AEP* | $AFGP_F$ | $P_FHP^*$ - FHE |
| Social surplus | | | - GEF |

7) Does this look familiar? It should, because the analysis is exactly the same as for the quota.
8) A quota is a *quantity-based* approach to limiting production.
9) A price floor is a *price-based* approach to limiting production.
10) The result is exactly the same, regardless of which approach you use.

**H) Price Ceiling**

1) When the government uses a price ceiling it establishes a maximum price at which a good can be sold.
2) The United States government used price ceilings during World War II to prevent the prices on consumer goods like bread, tires, gasoline and canned goods from rising.
3) During the 1970's much of the oil crisis was linked to the fact that the government placed a price ceiling on gasoline.

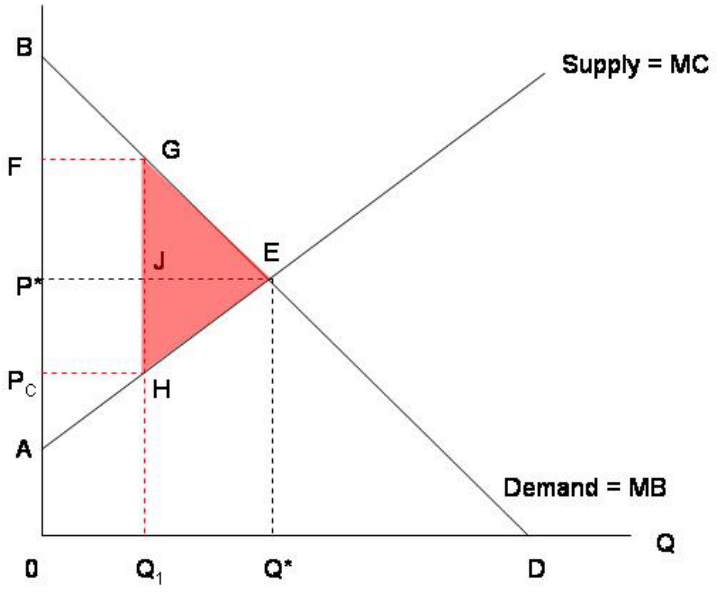
**Figure 15: A Price Ceiling**




4) Consider the market described by Figure 15. The equilibrium quantity and price in the unregulated market are Q* and P*.

5) Let's do a bit of quick review of the basics. In the unregulated market the
   a) *Gross benefits* of consumption are BEQ*0,
   b) *Costs of production* of the Q* units are AEQ*0,
   c) *Payments* from consumers to producers are (P*) x (Q*) = P*EQ*0
      *Consumer surplus* is BEP*
   d) *Producer surplus* is AEP*
   e) *Social surplus* is BEA
6) Note that the government is not involved directly in this market so the social surplus does not include any considerations of government.
7) Now suppose that the government decides that there needs to be a price ceiling $P_C$ in this market.
8) The price ceiling only affects the market if $P_C < P^*$.
9) If $P_C < P^*$ then the effect is to lower the quantity that suppliers are willing to supply. For the $P_C$ in Figure 1, the quantity drops from Q* to $Q_1$.
10) This lower quantity and price substantially change the consumer and producer surplus. The new figures are
   a) *Gross benefits* of consumption are $BGQ_10$,
   b) *Costs of production* of the $Q_1$ units are $AHQ_10$,
   c) *Payments* from consumers to producers are $(P_C) \times (Q1) = P_1HQ_10$
   d) *Consumer surplus* is $BGHP_C$
   e) *Producer surplus* is $AHP_C$
   f) *Social surplus* is BGHA

**Figure 16: Deadweight Loss with a Price Ceiling**




11) Total social surplus has declined by the amount GEH, the shaded area in Figure 16.
12) Consumer surplus has changed by the amount $+P^*JHP_C - GEJ$. Thus the sign of the change is indeterminate.

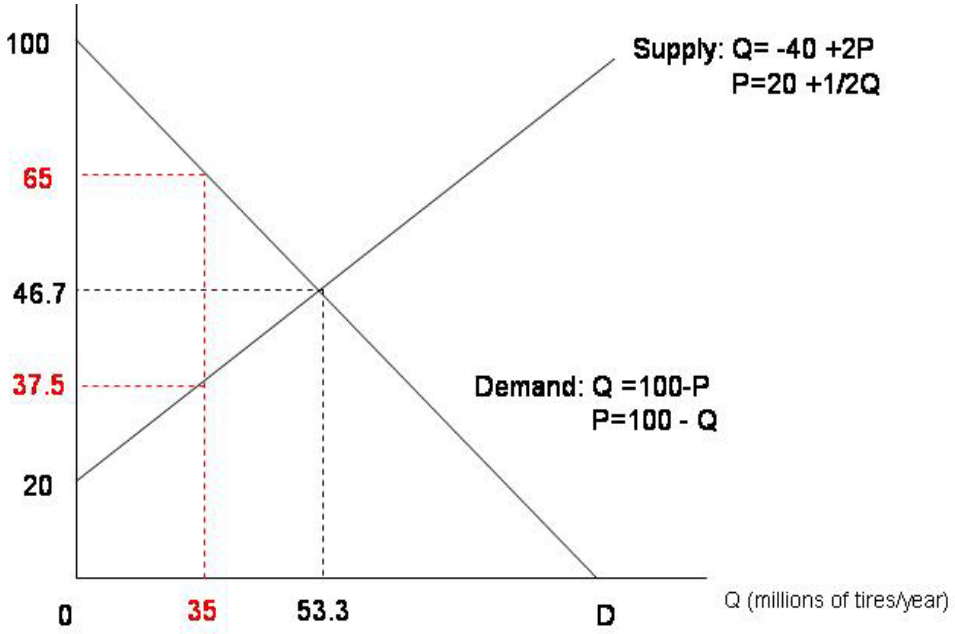
a) The first part of the change, $+P^*JHP_C$, represents an increase in consumer surplus due to the fact that there has been a decline in the price of the $Q_1$ units that are still produced. This is a transfer of surplus from producers to consumers.
b) The second part of the change, -GEJ, represents the loss in consumer surplus due to the fact that fewer units are produced. All of the consumer surplus associated with the reduction in production, $Q^*- Q_1$, is lost.

13) Producer surplus has unambiguously declined by and amount $P^*JHP_C$.
a) Of this $P^*JHP_C$ has been transferred to consumers due to the lower price.
b) The other JEH is lost producer surplus associated with the reduction in production, $Q^*- Q_1$.

14) Numerical example of a price ceiling.
a) Up to this point we have been using diagrams only to illustrate how prices, quantities, consumer surplus, producer surplus and social surplus change. We can apply those principles to analyze numerical examples.
b) Consider a hypothetical market for tires where the supply and demand equations in the market are described by
i) Supply $Q = -40 +2P$
ii) Demand $Q = 100 –P$
iii) P is \$/tire, and Q is millions of tires/year
iv) The relations apply only for $P \geq 0$ and $Q \geq 0$
c) Let's think about what this means
d) If the price of tires was P = 0 \$/tire, consumers would demand 100 million tires per year.
e) When the $P \geq 100$ \$/tire demand drops to Q = 0
f) Suppliers won't supply any tires if the price is below 20 \$/tire
g) For every one dollar increase in the price of tires, the quantity that producers are willing to supply rises by 2 million and the quantity consumers are willing to buy drops by one million.
h) How many tires are produced and sold in the unregulated market?
i) We know that producer price and consumer price are equal and production equals consumption when the market clears (this is the point where the two curves intersect). Therefore, we need to solve the above equations for P and Q. This works, because we have two equations and two unknowns.
ii) If Q is equal in the two equations, then
(A) $-40 + 2P = 100 – P$
(B) so, $3P = 140$ and $P = 46.67$
iii) Plugging this price back into the two equations we get
(A) Supply: $Q = -40 +2(46.67) = 53.33$
(B) Demand: $Q = 100 –46.67 = 53.33$
(C) It checks, i.e., the solution $P^* = 46.67$ and $Q^* = 53.33$ is a solution for both linear equations, there for it must be the point at which the two intersect.
iv) To diagram the supply and demand equations in the typical graph we must first solve for the inverse supply and inverse demand equations:

(A) Supply: P = 20 + ½ Q
(B) Demand: P = 100 – Q

**Figure 17: A Price Ceiling in the Tire Market**



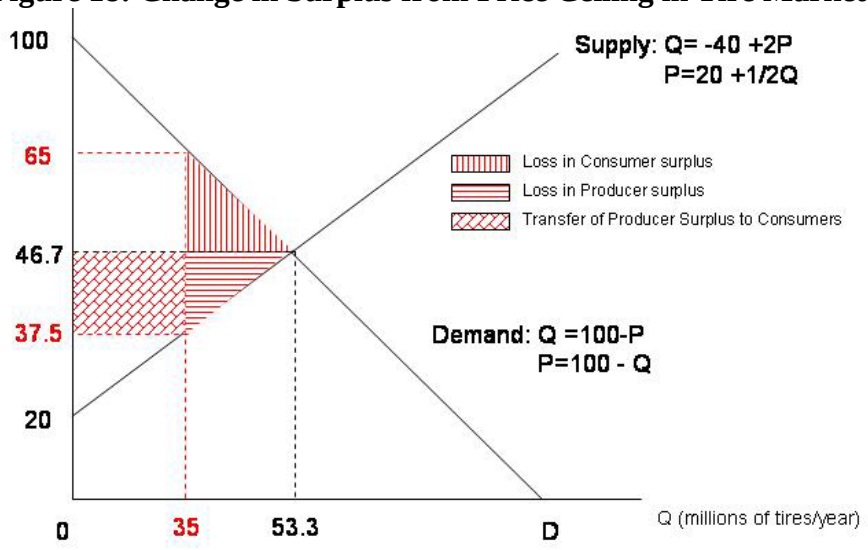

v) A representative diagram shows this relation in Figure 17

i) Now suppose the government places a price ceiling on the market of $37.50 per tire.

j) Note that this is lower than the market clearing price of $46.67/tire so the quantity that suppliers are willing to supply will decrease.

k) How many tires will producers supply at this new price? Check it with the supply function: Q = - 40 +2(37.5) = 35. So producers will supply 35 million tires per year at this new, lower price.

**Figure 18: Change in Surplus from Price Ceiling in Tire Market**

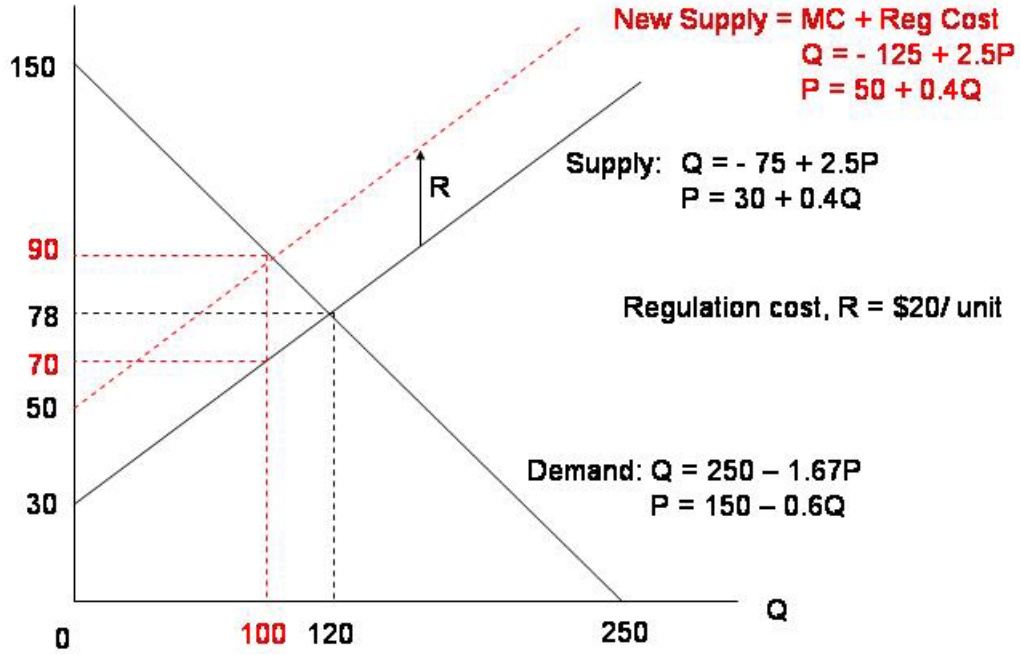


l) How do consumer, producer and social surplus change as a result of this price ceiling? See Figure 18.
m) Consumer surplus declines by ½ (65-46.7)(53.3-35) = $167.44, but receives a transfer of 35(46.7-37.5) = $322 from producer surplus, for a net gain of $154.56.
n) Producer surplus declines by (46.7-37.5)((½)(35+53.3)) = $406.18.
o) The net effect on social surplus is a decline of $406.18 – $154.56 = $251.62.
p) Notice that this is equal to the standard deadweight loss triangle in Figure 18 measured as ½ (65-37.5)(53.3-35) = $251.62

## I) Government Regulation

1) When the government regulates the production or use of a good it generally does so in a way that raises the effective cost of the good, which in turn affects consumer and producer surplus.
2) For our purposes we will consider a relatively simple case where the government regulates the production of a good in a way that raises the unit production costs uniformly across all levels of production.

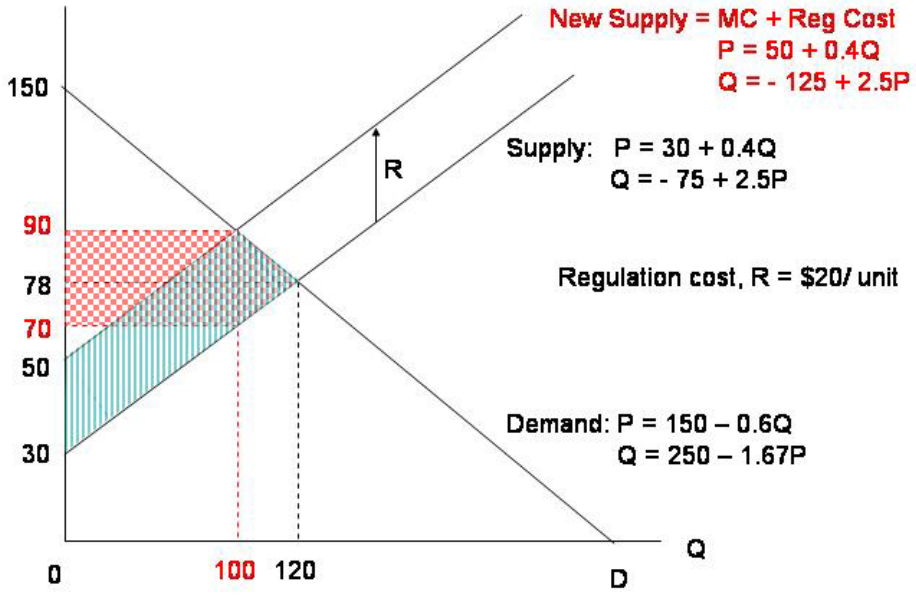
**Figure 19: Change in Market following Regulation**




3) Consider the market in Figure 19 where the pre-regulation conditions are
   a) Supply: Q = -75 + 2.5P
   b) Demand: Q = 250 – 1.67P
   c) Using the approach described above we find the equilibrium price, P = 78, and quantity, Q = 120, before the regulation.
4) Now suppose that the government implements a regulation that increases the marginal cost of production by $20 for all levels of production.

5) The regulation **essentially adds $20 to** P, for all values of Q, represented by the higher, dashed, supply curve.
6) To find the new supply curve, add $20 to pre-regulation inverse supply curve so P = (30 + 0.4Q) + 20 = 50+ 0.4Q
7) This is the new supply curve shown in red in Figure 19.
8) At this new, higher price, consumers will demand less. Find the intersection of the two curves:
   a) 50 + 0.4Q = 150 – 0.6Q => Q = 100
   b) Plugging this value of Q into either the new supply curve or the (unaltered) demand curve: Q = 100 => P = 90
   c) So the equilibrium after implementation of the regulation is P = 90, Q = 100
9) What is the social cost of the regulation?
   a) Before regulation
      i) Consumer surplus was ½ (150 -78) (120) = $4,320
      ii) Producer surplus was ½ (78-30)(120) = $2,880
   b) After regulation
      i) Consumer surplus is ½ (150-90)(100) = $3,000
      ii) Producer surplus is ½ (90 – 50)(100) = $2,000
   c) Change in
      i) Consumer surplus is -$1320
      ii) Producer surplus is -$880
      iii) Social surplus is -$2,200
   d) Note that we could have calculated the change in social surplus directly as
      i) Social surplus before regulation = ½(150-30)(120) = $7,200
      ii) Social surplus after regulation = ½ (150-50)(100) = $5,000
      iii) Change in social surplus = $2,200
      iv) In Figure 20, the loss in social surplus can be pictured as either of the two shaded areas

**Figure 20: Loss in Social Surplus Due to Regulation**

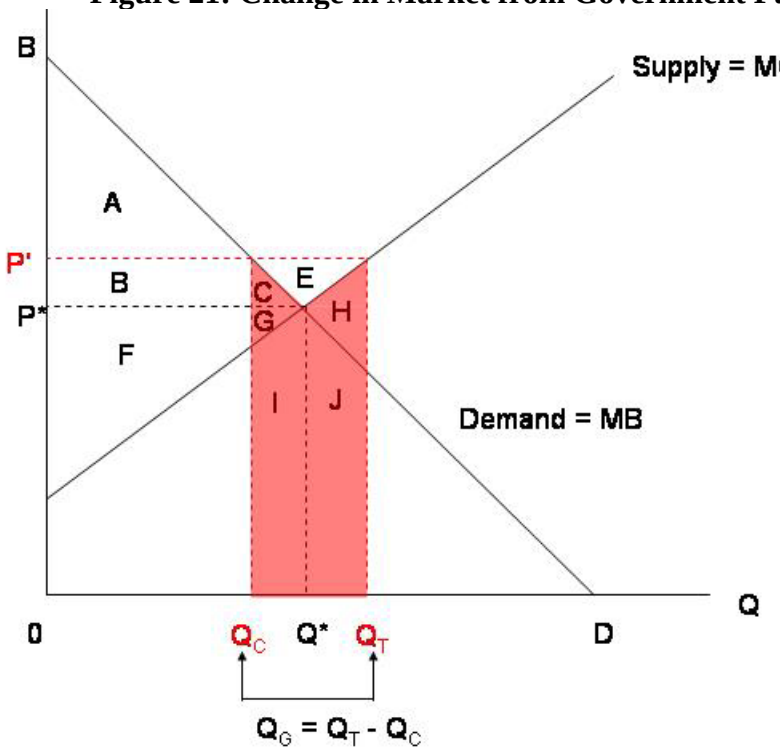


v) So what is the social cost of the regulation in this case? $2,200

**J) Government Purchases**

1) When the government acts as a small player in a market
   a) It does not significantly affect the market or the market price,
   b) The social cost of the government purchase is simply P * $Q_G$ where $Q_G$ is the quantity of the good that the government purchases. This is based on the assumption that the price the government pays reflects true social costs.
      i) Q: What conditions are necessary for that to be the case?
      ii) A: Perfectly competitive market.

**Figure 21: Change in Market from Government Purchase**

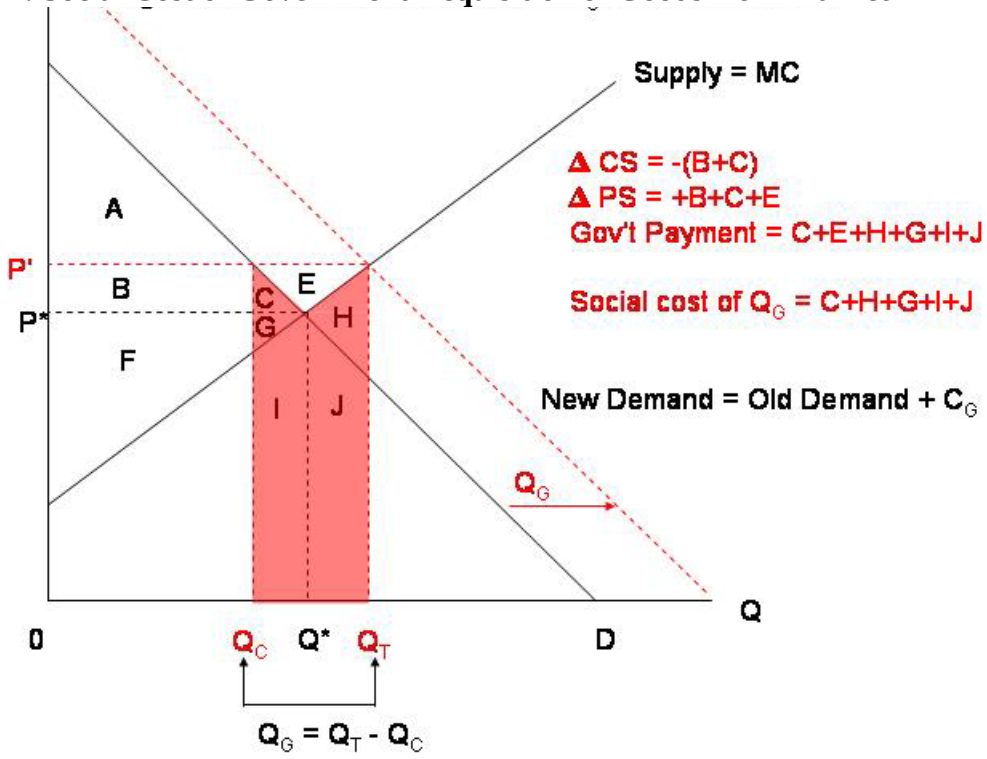



2) Sometimes the government enters the market with enough power to affect the price.
   a) Figure 21 shows a market in which the government enters with a purchace large enough to affect the price
      i) The price and quantity were at P* and Q* before the government entered the market to make purchases
      ii) The government enters the market and purchases $Q_G$ units of the good
      iii) We can guess that with the added demand from the government the price will go up and the amount that consumers purchase will go down from Q* to $Q_C$.
   b) There are at least two ways to analyze this
      i) The diagram in Figure 21 shows a shaded area that represents the social cost of the purchase. The area actually represents two types of cost

ii) Area CGI represents the loss in gross consumer benefits from the reduction in private consumption from Q* to $Q_C$.
iii) Area HJ represents the increase in production costs associated with the increase in total production from Q* to $Q_T$.

c) You can also think of this as a shift in the demand curve where the quantity demanded at any price increases by $C_G$ units. (See Figure 22)

**Figure 22: Social Cost of Government Acquisition of Goods from Market**




d) Consumer surplus
i) With the higher aggregate demand curve, the price rises to P' and private consumption falls to $Q_C$
ii) Consumer surplus falls from A+B+C down to A
iii) There is a change in consumer surplus of –(B+C)

e) Producer Surplus
i) Production rises from Q* to $Q_T$ and price rises to P'
ii) Producer surplus rises from F+G up to F+G+B+C+E
iii) Producer surplus rises by +(B+C+E)

f) Government Payment : The change for the government is -(C+E+H+G+I+J)

g) Sum across the three changes to get –(C+H+G+I+J)

h) This is the social cost of the government purchasing a non-marginal quantity of the good.