

## Economic Welfare and the concept of Deadweight Loss

The concept of deadweight loss (DWL) is one of the great contributions to policy analysis that you should take from a microeconomic principles course. This handout is intended to outline in detail the reasoning and intuition that underlie the concept.

A brief review of economic welfare must precede any discussion of DWL. Recall that welfare at a given quantity of a good is the benefits society receives from the quantity it consumes less the costs society pays at the quantity it produces. (For what remains, assume that individuals value goods and producers perceive costs in the same way as society, i.e., there are no externalities.)

Social benefits are measured as the total valuation of the benefits (i.e., willingness-to-pay) from the consumed quantity. This coincides with the area under the demand curve between the origin and the quantity that individuals consume.

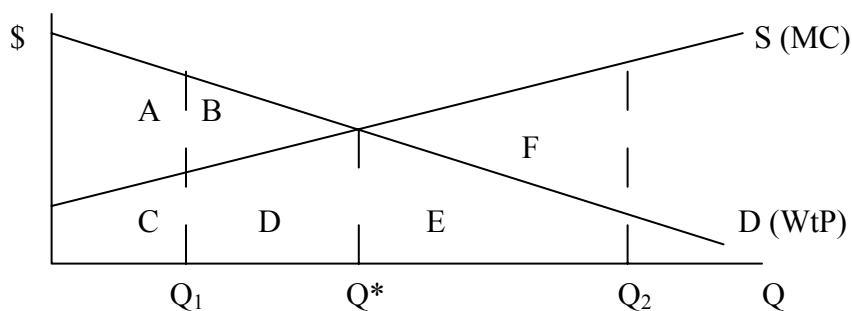
Social costs are measured as the total valuation of the costs (i.e., marginal costs) from the produced quantity. This coincides with the area under the supply curve between the origin and the quantity that producers supply.

### **Margi, the Benevolent Social Planner**

The imaginary benevolent social planner can help illustrate how competitive markets maximize welfare. For this example, the planner is named Margi after my mother, who always dreamed of this job. Imagine an all-knowing entity who:

1. can instruct the economy how much of every good is to be produced,
2. can produce that output with the lowest-cost suppliers, and
3. can assign that output to those members of society who value it most.

Consider the following graph showing the supply and demand of widgets.



First, Margi considers producing  $Q^*$ . This level of production entails costs of the area beneath the supply curve from the origin to  $Q^*$  (the area  $C + D$  on the graph above). If this production is assigned to those who value widgets most, then society benefits by the amount beneath the demand curve from the origin to  $Q^*$  ( $A + B + C + D$ ). Since economic welfare from the market for widgets is total benefits less total costs, welfare in this case is the area that lies between the demand and supply curves from the origin to  $Q^*$ :  $W^* = \text{Benefits}(Q^*) - \text{Costs}(Q^*) = (A + B + C + D) - (C + D) = A + B$ .

Now suppose that Margi considers producing  $Q_1$  widgets. (For purposes of generality, this can be any quantity less than  $Q^*$ ). Now society benefits by the area  $A + C$ . This is less than it benefited under production of  $Q^*$ , but note that society also pays lower costs. Specifically, now it only faces costs of the area  $C$ . The welfare ( $W_1$ ) generated by production and consumption of  $Q_1$  is then  $W_1 = A (= (A + C) - C)$ . This is clearly less than the welfare generated at  $Q^*$  (recall it was  $A + B$ ), so Margi will not choose to produce *less* than  $Q^*$  widgets.

Finally, Margi considers producing  $Q_2$  widgets. (Again for reasons of generality, this can be any quantity greater than  $Q^*$ .) Now society benefits by the area  $A + B + C + D + E$ . Margi is heartened by the fact that benefits are greater than when she produced  $Q^*$ , but she keeps in mind she must also consider costs. These costs are represented by the area  $C + D + E + F$ . Welfare ( $W_2$ ) at  $Q_2$  is then  $W_2 = A + B - F (= (A + B + C + D + E) - (C + D + E + F))$ . This is also clearly less than the welfare generated at  $Q^*$ , so Margi will not choose to produce *more* than  $Q^*$  widgets.

Since  $Q^*$  is the welfare-maximizing quantity of widgets, economists say it is the efficient level of consumption and production. Using the (inverted) interpretations of supply and demand, that efficient level occurs where the marginal consumer's willingness-to-pay equals the marginal producer's marginal cost.

If  $Q^*$  is efficient, then any other quantity of widgets is inefficient. The cost to society of that inefficiency is the deadweight loss (DWL). That cost is the difference between welfare at  $Q^*$  and welfare at another specific quantity. In the case of  $Q_1$ , this DWL is the area  $B$  ( $DWL = W^* - W_1 = (A + B) - A = B$ ). This is the cost of missed opportunities: there were consumers in the economy who valued widgets at more than their marginal cost of production, but they did not get to consume them. This DWL then results from underconsumption.

What about  $Q_2$ ? The DWL at that quantity is the area  $F$  ( $DWL = W^* - W_2 = (A + B) - (A + B - F) = F$ ). This is the cost of overconsumption: there were consumers in the economy who got widgets even though they did not value them at more than their marginal cost of production.

The beauty of the unregulated price system in competitive markets is that the equilibrium market price yields the transacted quantity of  $Q^*$ . (Recall that this happens since the market price will adjust until the quantity demanded equals the quantity supplied, i.e., the market price is that price where supply and demand intersect.) This insight is the First Fundamental Theorem of Welfare Economics, occasionally termed the Invisible Hand Theorem.

The value of the DWL concept is in its applications to three basic scenarios: 1) when governments interfere with markets through taxes, subsidies, or direct price controls, 2) when markets are not competitive, and 3) when markets for goods exhibit externalities. For the time being, I will consider four variations of the first scenario. Below you will find questions that should further illustrate the DWL concepts.

### **The impact of taxes**

Draw a graph that illustrates the effect of a unit tax ( $P^D = P^S + \text{Tax}$ ) compared with the no-tax case. (Recall the irrelevance of legal incidence of taxes when conducting an economic analysis.) Be sure to label the pre-tax price and quantity as well as the post-tax price(s) and quantity. Use this graph to answer the following questions.

- 1) Is any of the good that is produced not consumed, i.e., is there any waste?
- 2) Will those consumers with the highest valuations get the good?
- 3) Will those producers with the lowest marginal costs supply the good?
- 4) If you answered 'No' to either of the prior two questions, what does that imply about the precision of your graph's measure of welfare to actual welfare?
- 5) Is the post-tax quantity lower or higher than the pre-tax quantity? What interpretation(s) will the DWL from the tax then have?
- 6) Locate the area that is DWL on your graph. How would you measure/approximate the economic welfare that is lost because of the tax?

### **The impact of subsidies**

Draw a graph that illustrates the effect of a unit subsidy ( $P^D = P^S - \text{Subsidy}$ ) compared with the no-subsidy case. As above, recall the irrelevance of legal incidence. Label all prices and quantities under the pre-subsidy and post-subsidy cases, and use the graph to answer the following questions.

- 1) Is any of the good that is produced not consumed, i.e., is there any waste?
  - 2) Will those consumers with the highest valuations get the good?
  - 3) Will those producers with the lowest marginal costs supply the good?
  - 4) If you answered 'No' to either of the prior two questions, what does that imply about the precision of your graph's measure of welfare to actual welfare?
  - 5) Is the post-subsidy quantity lower or higher than the pre-subsidy quantity? What interpretation(s) will the DWL from the subsidy then have?
  - 6) Locate the area that is DWL on your graph. How would you measure/approximate the economic welfare that is lost because of the subsidy?
- Feel free to replicate the above exercises for ad valorem (percentage) taxes ( $P^D = (1+t)P^S$ ) and subsidies ( $P^D = (1-s)P^S$ ).

### **The impact of price ceilings**

Draw a graph that illustrates the effect of a binding price ceiling ( $P^* > P_{\text{Ceiling}}$ ) compared to the no price control case. Label all prices and quantities, and use the graph to answer the following questions.

- 1) Is any of the good that is produced not consumed, i.e., is there any waste?
- 2) Will those consumers with the highest valuation get the good?
- 3) Will those producers with the lowest marginal costs supply the good?
- 4) If you answered 'No' to either of the prior two questions, what does that imply about the precision of your graph's measure of welfare to actual welfare?
- 5) Is the ceiling quantity lower or higher than the no-ceiling quantity? What interpretation(s) will the DWL from the price ceiling then have?
- 6) Locate the area that is DWL on your graph. How would you measure/approximate the economic welfare that is lost because of the price ceiling?

**\*\*THIS IS THE TRICKIEST ONE\*\***

### **The impact of price floors**

Draw a graph that illustrates the effect of a binding price floor ( $P^* < P_{\text{Floor}}$ ) compared to the no price control case. Label all prices and quantities, and use the graph to answer the following questions.

- 1) Is any of the good that is produced not consumed, i.e., is there any waste?
- 2) Will those consumers with the highest valuation get the good?
- 3) Will those producers with the lowest marginal costs supply the good?
- 4) If you answered 'No' to either of the prior two questions, what does that imply about the precision of your graph's measure of welfare to actual welfare?
- 5) Is the price floor quantity lower or higher than the no-floor quantity? What interpretation(s) will the DWL from the price floor then have?
- 6) Locate the area that is DWL on your graph. How would you measure/approximate the economic welfare that is lost because of the price floor?

Successful completion of these general exercises should provide good practice for the applications of DWL to the cases of monopoly (or more generally firms with market power) and externalities (such as education and pollution).