

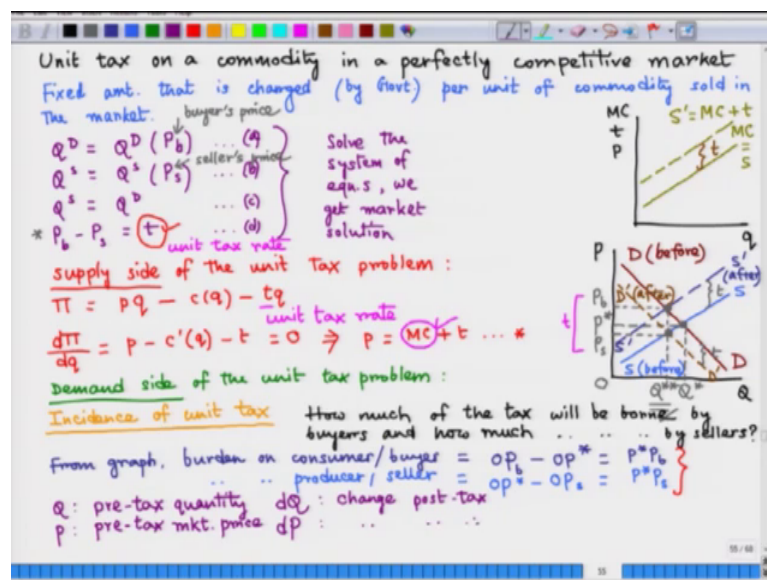
Microeconomics: Theory & Applications.
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Lecture – 42

Welfare Analysis of Government Intervention in Competitive Market (Part - 1)

Hello, welcome back to the lecture series on Microeconomics. Last time, we have discussed first welfare theorem and now we are going to continue our discussion on the violations of the assumptions that we make to have a perfectly competitive market working and they are implications. We will start our discussions with the case of unit tax imposed by a government.

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So, what is a unit tax? So, this is basically a fixed amount that is charged by government of course, per unit of commodity sold in the market.

So now, we are going to write a simple mathematical model to find the implications of imposition of unit tax on a particular commodity. So, we are going to write these equations. So, Q^D is basically quantity demanded and that is basically a function of the price that buyers pay. So, that is basically my equation number a then quantity supply is basically a function of the price that seller receives and that is denoted by P_s that is my equation number b and of course, we know to find market equilibrium, we need to have Q_s equal to Q^D market demand shall meet market supply at the equilibrium price and

that equilibrium condition gives in my equation c in the model. And there is another equation a fourth one, which is basically the difference between this price that buyers pay and sellers receive and that is basically the amount of unit tax imposed by the government, that is basically my equation number d.

So, when we solve this system of equations, we get market solution. Now we are going to show that that solution is suboptimal because, it generates deadweight loss or it gives rise to deadweight loss. Before, we draw a graph and show deadweight loss in this case let us think, how to approach to solve this model mathematically. Now we can take 2 different approaches, we can either shift the demand function or we can shift the supply function, let us first think about the supply side of the story. So, we will first start with the competitive firm. So, a competitive firm has a profit maximization problem, they are we know how to proceed the revenue. So, the profit is equal to revenue minus the cost of production minus the tax that the firm should pay right. So, this is basically the t , which is the unit tax rate ok.

So, we know what to do; we need to take derivative of this profit function to maximize profit and that derivative shall be with respect to quantity, because that is what the firm decides. So, the firm gets P minus c prime q minus t and we need to set that to 0 and what is the implication of this first order condition? We get price equals to marginal cost plus t . So, that is basically the result that is going to be critical in this case. So, the star is basically the first order condition that the firm needs to satisfy in the case of a unit takes in position now note at this MC component. So, MC is basically a part of MC is basically the supply function of the firm and as t is a positive number so; that means, that if the government imposes unit tax on the commodity that, this perfectly competitive firm sells then the supply function shifts upward to the left and the difference between the initial supply curve and the new supply curve after tax imposition gives the rate of the tax.

So, if I want to draw a diagram. So, this is small q of particular firm's output level in competitive market and price and MC that I plot along the vertical axis and t as well. So, in that case if we start with some initial supply function, I assume this to be a straight line marginal cost curve without loss of any generality. So, this is basically individual firms supply function right. So, if there is a case of unit tax this supply function shall shift up. So, the supply curve shall shift left ward and this broken line gives me the changed supply function, which can be denoted by S prime and that is exactly equal to

MC plus t where t is the unit tax. So, this difference that we observe here is basically the unit tax rate that is imposed by the government. So, this is exactly what is happening to a particular firm. Now let us get into the deeper details of the supply side of the story.

So, if a particular competitive firm supply function shifts left, shifts upward then the horizontal sum of all competitive firm supply shall give rise to a new industry supply or aggregate supply function and that new aggregate supply function, which is after tax imposition shall also shift upward, I mean lift ward from the original location of the supply function and this is due to the imposition of the tax. So, one approach to model the implication of unit tax imposition is by shifting the market supply function or the aggregate supply function in the traditional competitive market demand supply diagram.

So, now I am going to plot that conventional competitive equilibrium conventional perfectly competitive market diagram, where we have quantity Q as the market quantity bought and sold and price P measured along the axis. And suppose, we start with the demand function a straight line downward sloping function without loss of any generality; let me call this D . Now let us impose the supply function and let me impose the supply function, which is also a straight line and this is market supply original.

So, that is basically before tax, let me write this down. So, this is before tax and let me also write down your the same thing. So, that later we do not get confused. So, this is D before right. So, the initial equilibrium the perfectly complete equilibrium is to be obtained at the intersection point, we all know that and the equilibrium market price and quantity are determined say, Q^* is the perfectly competitive equilibrium output level and P^* is the perfectly competitive price right.

Now, if there is unit tax t imposed then there will be a shift in the supply function and the supplied aggregate supply function is S shall shift upward and that can be given by this blue broken line and I call this S' . So, this is my supply function after the tax ok. Now a new equilibrium will be obtained at the intersection of this new supply function and the original demand function D . Of course, there will be some quantity that will clear the market it implies the demand shall be equal to supply and let that quantity level the Q' right. So, when in a perfectly competitive market, the

aggregate supply function of the market supply function shifts upward then what does that mean? That means that the buyer has to pay now extra price right.

So, there is a difference between the price that the buyer actually pays and the equilibrium market price. So, then we observe what buyers actually pay inclusive of tax and then you know, there is a difference between what buyers pay and what is the equilibrium price. Now we can analyze the case of unit tax imposition from the demand side as well and in that case, we have to shift the demand function, but here remember never shift both the demand and supply functions. So, either you shift the demand function or you shift the supply function to analyze the implication of unit tax imposition on a commodity ok.

So now, let us study the demand side of the story. So now, in the case of demand side we are going to study, how it is going to impact the demand function of the market right. So, if government imposes some t dollars of tax then basically, we have to shift the demand function parallelly downwards and we can draw that shifted demand function through this broken brown straight line and we call it D' to denote the after demand function.

So, let me write after here right ok. So, in the second case where, we have shifted the demand function in response to the imposition of unit tax, what we observe? We get the price that sellers actually receive net of tax. Now let us go back to our diagram and let us analyze. So, in this case also we see that there will be an equilibrium of course, to be obtained at the intersection between the original supply function SS because, we have not shifted that curve, we have only shifted the demand function. So, the intersection will be now between SS curve and the D' curve and a new market price will be obtained note that the way, we have drawn the equilibrium quantity level is basically same in both the cases.

Because, we are talking about the parallel shift of the demand function or the supply function by the same magnitude right and the magnitude is basically the tax rate t . So, although in the diagram it may not look to be same, but please note that the difference between the broken line and the solid line is basically, fixed constant and that is basically the rate of unit tax ok. So now, let us see that actually there are although the quantity

bought and sold in the market is same in 2 treatments that we have given to this simple model, but the prices actually are different.

So here, in the first case, when we have shifted the supply function, we get the price P_b , which is basically higher than the equilibrium price P^* that is basically, the buyers price right. So, if you note our equation a here, we have already specified this demand function as a function of buyers price or price that buyers face after tax imposition and in the second case, where we have shifted the demand function down and kept the supply function intact there, we observe a lower price market price, which is given or denoted by say P_s and that is basically, we call sellers price or the price that sellers receive net of tax and earlier in our mathematical model, we have assumed that our supply is a function of P_s right ok. So here, we see that there is a difference between the price that buyers pay in first approach and the price, what sellers receive in the second approach and I want to draw your attention to the difference of these 2 prices the difference between P_b and P_s exactly the amount of tax that the government imposes on 1 particular, 1 unit of the particular commodity, which is basically given by our equation d in our mathematical model.

So here, I would like to draw your attention to this particular equation, which says that the difference between P_b and P_s . So, P_b and P_s is basically t right fine, now a very interesting question that comes to mind is this. So, when government imposes rupee 1 or dollar 1 tax on a particular commodity, how the price is going to react to that, do we see 1 dollar or 1 rupee increase in the market price of the commodity? Or the question can also be another question can be asked that if a 1 rupee or 1 dollar tax is imposed on a commodity, who will take the burden of that tax? So, who will pay that tax, is it going to fall upon the shoulder of the buyers or is it going to be borne by the suppliers or the sellers?

Now, we are going to study mathematically to find answers to these sorts of interesting questions. So now, we are going to enter this area, what is known as incidence of a tax. Let me be very clear here, we are going to discuss a very simple case the incidence of tax can be really complicated in real life, where we work with non-linear demand and supply and complicated market structures, but here let us assume that, we deal with a very simple model ok. So, what do we mean by incidence of unit tax? So, let me define that. So, this actually means how much of the tax will be borne by buyers and how much will

be borne by sellers? So, let us study the graph first. So, from graph the consumers or buyers the burden, let me note the origin here O.

So, OP_b minus OP_s right and let us now find out the burden on producer or seller and that would be equal to OP_s minus OP_b right and that is basically the distance P_s P_b and similarly, we can see from the graph that the consumers burden would be P_s P_b right. So, this is what we observe from the graph. Now can we find some mathematical formula, which can talk about the exact distribution of these tax burden on the consumers and the producer because, a graph is a graph right. So, if you draw the demand function and the supply function with different slopes and intercept, you may get different P_b P_s and P star values and of course, these graphical magnitudes will vary from one graph to the other.

Hence, some mathematical treatment is required to find the incidence of tax on the consumers and the producers in a robust manner. So now, let us assume that Q is basically my pre tax quantity bought and sold in the market and then of course, dQ is basically the change that is observed post tax imposition ok. Similarly we can assume P to be the pre tax market price hence, dP is basically change in the market price post tax right ok.

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Handwritten mathematical derivation of tax incidence formulas:

$$\begin{aligned} & \bullet \frac{dQ}{Q} = |E_D| \cdot \frac{dP_b}{P} \\ & \bullet \frac{dQ}{Q} = E_S \cdot \frac{dP_s}{P} \end{aligned} \quad \left. \vphantom{\begin{aligned} & \bullet \frac{dQ}{Q} = |E_D| \cdot \frac{dP_b}{P} \\ & \bullet \frac{dQ}{Q} = E_S \cdot \frac{dP_s}{P} \end{aligned}} \right\} \begin{aligned} & |E_D| \cdot \frac{dP_b}{P} = E_S \cdot \frac{dP_s}{P} \\ \text{or, } \frac{dP_b}{dP_s} &= \frac{E_S}{|E_D|} \dots (*) \end{aligned}$$

t per unit tax. $t = t_b + t_s$

$(t_b = dP_b)$ Buyer's tax incidence Seller's tax incidence $(t_s = -dP_s)$

$$\frac{t_b}{t_s} = \frac{E_S}{|E_D|}$$

$$\text{or, } \frac{t - t_s}{t_s} = \frac{E_S}{|E_D|} \Rightarrow \frac{t}{t_s} = \frac{E_S}{|E_D|} + 1 = \frac{E_S + |E_D|}{|E_D|}$$

$$\text{or, } \frac{t_s}{t} = \frac{|E_D|}{E_S + |E_D|}$$

So now, I would like to draw your attention to 1 formula that we have used earlier, we have introduced earlier and that is basically the concept of demand elasticity or price

elasticity of demand right. So, if we adopt that formula we can from that that, if we rearrange the formula then we get this right and as we know that generally demand elasticity is negative.

So, we have to work with the absolute value and then it is perfect similarly, we can use another concept, which have been introduced before and that is the elasticity of supply and if we rearrange the formula for elasticity of supply then basically, we get elasticity of supply well, I can write this d here to denote demand that will be more straightforward ok. Now, let us get back to the formula for elasticity of supply, we have elasticity of supply times change in producers price divided by the market price right ok. So, from this 2, I can also write ok. So, one can write $d P_b d P_s E_s$ divided by E_D right, we know that t is basically our per unit tax, when it is imposed in the market by government will be shared between the buyers and the sellers.

So, we can write t equals t_b plus t_s where t_b is basically, buyer's tax share or tax incidence and t_s is basically sellers tax incidence. Now note that these P_s can be rewritten as negative change in the producers price and similarly, the buyers tax incidence can be rewritten as t_b equals the change in the buyers price right. So, if we mark this expression, by say star from and this expression by double star combining star and double star. So, we have to utilize this fact and that fact into to rewrite the expression given by star and then, we can actually write t_b divided by t_s shall be equal to elasticity of supply divided by the elasticity of demand, it is absolute value right ok, now we can write t minus t_s .

So, we can now focus on these tax incidence on the buyers note that by utilizing this expression double star for this t_b element, one can write t_b as t minus t_s and then this will become. So, we can from here we can write t divided by t_s equals E_s divided E_D plus 1. So, we get E_s plus E_d divided by E_d right. So now, note that this is interesting because, it says something more and we can look at that thing, when we take inverse of this. So, let us rewrite t_s divided by t and that will give E_D divided by E_s plus mod value of E_D right.