Lecture Note 7 – From Individual Demand to Market Demand: The Incidence of a Tax

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1 From Individual Demand to Market Demand

- In developing consumer theory, we've studied the determination of demand at the level of an individual consumer.
- But consumers do not operate in isolation; they interact with one another, and with producers in a market setting.
- We now work our way up from the level of individuals to the level of markets. We'll do this in two steps.
  1. In the first step, we'll consider the market for a single good in isolation, such as automobiles or nutritive sweeteners (AKA, sugar). Studying a single market is generally referred to as a partial equilibrium analysis. That's because we ignore the relationship between prices and quantities in one market and prices and quantities in all other markets. For many applications, that's entirely fine. If we want to know how a $100 change in the price of Chevrolets affects consumer welfare, we are safe to ignore how this price change affects employment of GM workers, how it affects pollution levels faced by urban residents, how it affects global warming, etc.
  2. After the first exam, we'll move to general equilibrium analysis in which we consider the interaction of all markets simultaneously. In many cases, general equilibrium is a step too far. But some of the greatest insights of neoclassical economics come from the study of general equilibrium. And moreover, some problems *cannot* be correctly analyzed without using general equilibrium reasoning (e.g., the effects of international trade on welfare). Thus, the study of general equilibrium is well worth the effort. But that's not the place to start.

1.1 Where do market demand curves come from?

- You're probably familiar with this already, but it's worth stating again. The market demand curve is the sum of individual demand curves. So, if we have a set of Marshallian demand curves $d_{x,i}(p_x, p_y, I_i)$, then the demand curve at the market level is:

$$D_x(p_x) = \sum_i d_{x,i}(p_x, p_y, I_i).$$

- Concretely, imagine announcing a price p_x and asking each person in the market how much X they'd like to buy at that price. The market demand is simply the sum of their individual demands. Some consumers will want more X than others at any given price, and some will want none at all. But clearly, the lower is p_x, the more X will be demanded in aggregate, and vice versa for higher p_x. (Even if some consumers have Giffen demand for X over some range, it's likely that aggregate demand will be downward sloping in p_x since these Giffen consumers are likely to be a small minority.)

- Of course, market supply curves follow the same logic. We could announce a price p_x and survey each producer to find out how many X they'd be willing to supply at that price. The market supply is the sum of producers' willingness to supply X at each price p_x :

$$S_x(p_x) = \sum_i s_{x,i}(p_x)$$

This curve will be upward sloping in p_x. (And no, there no such thing as 'Giffen' supply of a good; firms have profit functions but not utility functions, and so there are no income effects to generate Giffen behavior.)

- And of course, the market clearing price of X is the one that equates supply with demand:

$$D_x(p_x^*) = S_x(p_x^*).$$

At this price, there is no consumer who would be willing to pay more than p_x^* for an additional unit of X, nor is there a producer who would be willing to produce an additional unit of X at a price less than p_x^*. So, p_x^* is an efficient price in that there is no other price that could (a) make both producers *and* consumers better off; or (b) make consumers *or* producers sufficiently better off that they could compensate the other party for its loss and still be better off.

1.2 Putting this apparatus to work

- You've probably used demand and supply curves elsewhere to study how price or quantity restrictions affect consumer and producer surplus. This is a good use of the tool, and we'll apply the same reasoning to the study of sugar quotas in the lecture next week.

- But we're going to start off with an application you may not have seen, which is the study of 'incidence.'

- Incidence refers to the allocation of a cost among various parties. For example, if the government places a 10 percent tax on gasoline, who bears the incidence of that tax? The naive answer is that it is all borne by consumers—after all, they pay the tax at the pump. So, nominally, the incidence falls on the consumer. But in real terms, the incidence is likely to be borne by both consumers and producers.

2 Incidence analysis

- Let's start with the example above. Suppose there is a \$0.10 market wide federal tax per gallon of gasoline ($\tau = 0.10$) levied on consumers. Assume that the price of gas initially is p_0. What is the taxed price, p_τ?

- It's tempting to answer that $p_\tau = p_0 + \tau$. But consider carefully if that answer makes sense.

- At the initial market equilibrium we had

$$D_x(p_0) = S_x(p_0).$$

If we conjecture that $p_\tau = p_0 + \tau$, this would imply that

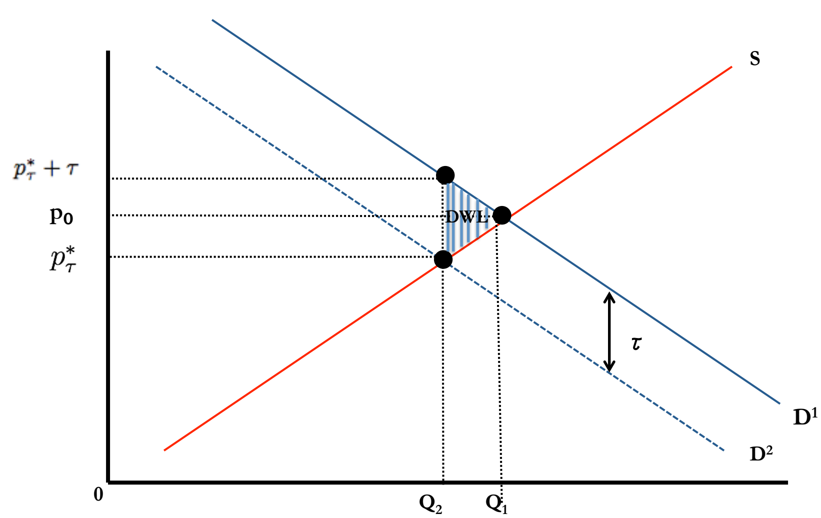
$$D_x(p_0 + \tau) = S_x(p_0).$$

Notice that since the tax is paid to the government, what the consumer pays at the pump is not what the producer receives. If the consumer pays $p_0 + \tau$, the producer receives only p_0.

- Inspecting the equation above, it seems very unlikely that $p_\tau = p_0 + \tau$. Assuming that $\partial D_x / \partial P_x < 0$ (i.e., demand slopes downward), it must be the case that $D_x(p_0 + \tau) < D_x(p_0)$ which implies that $D_x(p_0 + \tau) < S_x(p_0)$. So, at price p_0 there is excess supply of X.

- If the supply curve is upward sloping, there will be a slightly smaller quantity of X available at a slightly lower price than p_0. Thus, price will fall very slightly from p_0 to p_0', and quantity demanded will rise slightly from $D_x(p_0 + \tau)$ to $D_x(p_0' + \tau)$. And this process will repeat until we reach an equilibrium where

$$D_x(p_\tau^* + \tau) = S_x(p_\tau^*).$$



- In general, it will be the case that $p_\tau^* + \tau > p_0 > p_\tau^*$. That is, the consumer will pay a higher after-tax price than he or she paid prior to the introduction of the tax, and the firm will receive a lower after-tax price than it received prior to the introduction of the tax.

- The figure above shows this visually. The tax shifts the consumer demand curve down, from $D^1(p) = D_x(p)$ to $D^2(p) = D_x(p+\tau)$, since the consumers need to pay τ to the government in addition to p to the producer. The quantity at which the new demand curve and supply curve intersect is Q_2. Notice that the price received by producers, $p_\tau^* < p_0$, and the price paid by consumers $p_\tau^* + \tau > p_0$. The government collects τ.

- The share of the tax borne by the consumer is:

$$I_c = \frac{p_\tau^* + \tau - p_0}{\tau}.$$

  And the share of the tax borne by the producer is:

$$I_p = \frac{p_0 - p_\tau^*}{\tau}.$$

  You can confirm that these sum to the total tax:

$$I_c = \frac{p_\tau^* + \tau - p_0}{\tau} + \frac{p_0 - p_\tau^*}{\tau} = \frac{\tau}{\tau} = 1$$

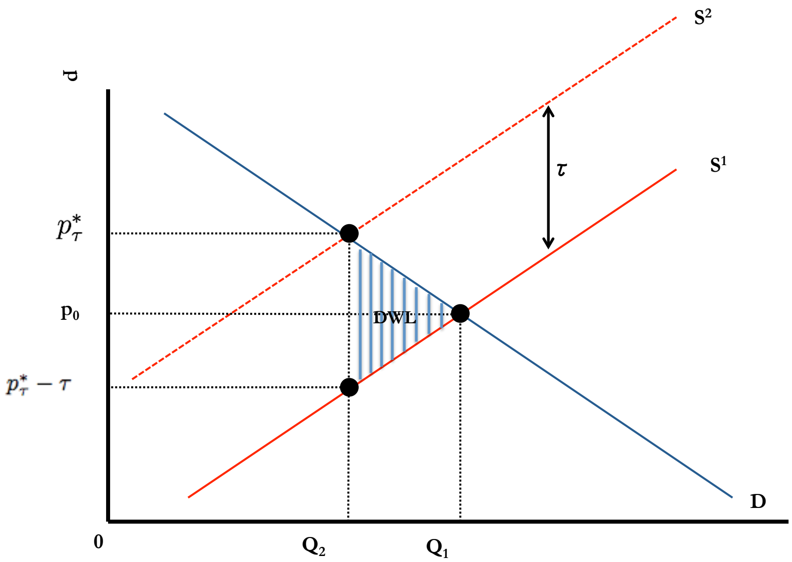
2.1 The irrelevance of the nominal tax burden

- Consider what happens if the government instead places the tax on producers rather than consumers.

- Again, we want to find a price, p_τ', so that the market clears. In particular p_τ' solves:

$$D_x\left(p_\tau'\right) = S_x\left(p_\tau' - \tau\right).$$

  We set up the problem here to reflect the fact that the consumer pays the market price, and then the firm pays the tax to the government. In the previous setup, the government collected the tax directly from the consumer.



- As shown in the figure above, this time, the supply curve shifts up because the producers need to pay τ to the government.

- Are the two problems equivalent in terms of quantities and the total prices paid/received net of the tax? To determine this, we can rewrite the producer-side tax problem as a consumer side tax. Let $p''_\tau = p'_\tau - \tau$ equal the price the firm receives. The price the consumer pays is then $p''_\tau + \tau$.

$$D_x(p'_\tau) = S_x(p'_\tau - \tau) \Rightarrow D_x(p''_\tau + \tau) = S_x(p''_\tau).$$

  There's no sleight of hand here. We are simply substituting p''_τ for $p'_\tau - \tau$.

- But expressed in these terms, we already know that the solution to this problem:

$$\begin{aligned} D_x(p''_\tau + \tau) &= S_x(p''_\tau), \\ D_x(p^*_\tau + \tau) &= S_x(p^*_\tau), \end{aligned}$$

  which implies that $p''_\tau = p^*_\tau$ and $p'_\tau = p^*_\tau + \tau$.

- What this means is: whether we nominally levy the tax on the consumer or producer, the consumer pays the same amount in either case and the producer receives the same amount in either case. That is, the incidence of the tax does not depend upon the identity of the nominal payee.

2.2 What *does* the Economic incidence depend upon?

- If the incidence does not depend upon which party the tax is nominally levied on, what does it depend on?

- Here, it's easier to work in elasticities. Let ε_d equal the market demand elasticity,

$$\varepsilon_d = \frac{\partial D_x}{X} \cdot \frac{P}{\partial P} < 0.$$

- Let ε_s equal the market supply elasticity,

$$\varepsilon_s = \frac{\partial S_x}{X} \cdot \frac{P}{\partial P} > 0$$

- Start again at price p_0, an equilibrium price with

$$D_x\left(p_0\right) = S_x\left(p_0\right).$$

- We impose the tax τ on consumers (or producers, equivalently), and we are looking for the new equilibrium price. The new equilibrium will involve a price p_τ^* where the price the consumer pays is τ more than the price the firm receives, and at this pair of prices ($p_\tau^* + \tau$, p_τ^*), the quantity demanded and supplied are equal, i.e. $D_x(p_\tau^* + \tau) = S_x(p_\tau^*)$.

- If this tax were paid entirely by the producer, quantity supplied would fall by $\frac{\tau}{p_0}\varepsilon_s > 0$ percent. Likewise, if the tax were paid entirely by the consumer, the quantity demanded would fall by $-\frac{\tau}{p_0}\varepsilon_d > 0$. Neither can be an equilibrium since if the tax is paid entirely by one side, we are left with either excess demand or supply of the good in the market.

- Therefore, it must be that $p_\tau^* \leq p_0 \leq p_\tau^* + \tau$. In math, if $p_0 < p_\tau^*$, then $S_x(p_\tau^*) > S_x(p_0) = D_x(p_0) > D_x(p_\tau^* + \tau)$. Likewise, we can show that $p_\tau^* + \tau \geq p_0$.

- So, who pays what portion of the tax? If producers get p_τ^* when a tax τ is charged to consumers, the percent change in quantity demanded is

$$\begin{aligned} \frac{D_x(p_\tau^* + \tau) - D_x(p_0)}{D_x(p_0)} &\approx \frac{\partial D_x(p_0)}{\partial p} \times \frac{p_\tau^* + \tau - p_0}{D_x(p_0)} \\ &= \varepsilon_d \left(\frac{p_\tau^* + \tau}{p_0} - 1\right). \end{aligned}$$

The term $\frac{p_\tau^* + \tau}{p_0} - 1$ is the percent change in price for consumers. So, it is not surprising to see the elasticity of demand here.

Likewise, the percent change quantity supplied is

$$\begin{aligned} \frac{S_x(p_\tau^*) - S_x(p_0)}{S_x(p_0)} &\approx \frac{\partial S_x(p_0)}{\partial p} \times \frac{p_\tau^* - p_0}{S_x(p_0)} \\ &= \varepsilon_s \left(\frac{p_\tau^*}{p_0} - 1 \right). \end{aligned}$$

The term $\frac{p_\tau^*}{p_0} - 1$ is the percent change in price for the producers.

- Since the change in quantities above must be equal in equilibrium, it must be that

$$\begin{aligned} \varepsilon_d \times (p_\tau^* + \tau - p_0) &= \varepsilon_s \times (p_\tau^* - p_0) \\ \implies \quad p_0 - p_\tau^* &= -\tau \frac{\varepsilon_d}{\varepsilon_s - \varepsilon_d} \end{aligned} \tag{1}$$

  Therefore, the price the producers recieve falls by $\tau \frac{\varepsilon_d}{\varepsilon_s - \varepsilon_d}$. Effectively, the producers only pay $\frac{\varepsilon_d}{\varepsilon_s - \varepsilon_d}$ fraction of the tax.

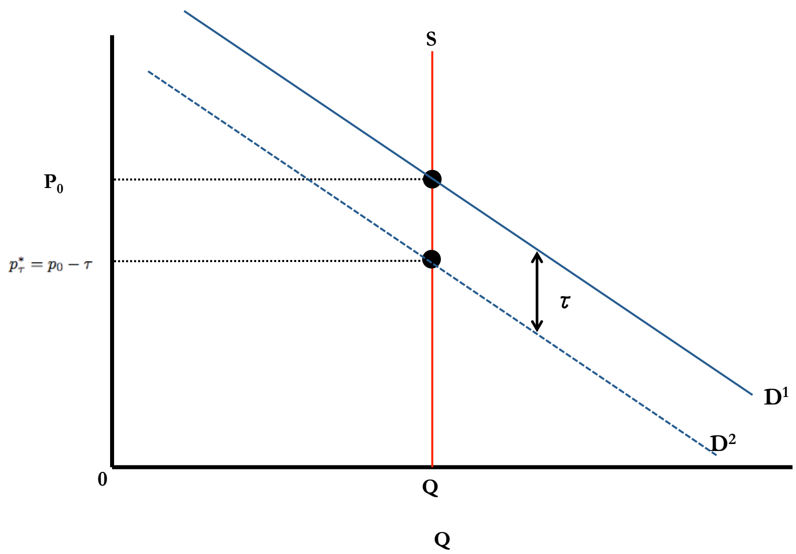
- Similarly, the price paid by consumers changes by $p_\tau^* + \tau - p_0 = \tau \frac{\varepsilon_s}{\varepsilon_s - \varepsilon_d}$. Consumers therefore only pay $\frac{\varepsilon_s}{\varepsilon_s - \varepsilon_d}$ fraction of the tax.

- This split of the tax has an intuitive interpretation. It says that the share of the tax borne by consumers is proportional to the elasticity of supply and the share of the tax borne by producers is proportional to the elasticity of demand.

- Concretely, if demand is very elastic (e.g., $\varepsilon_d = -3$) and supply is relatively inelastic (e.g., $\varepsilon_s = 0.5$), consumers dramatically reduce demand when prices rise but suppliers don't reduce supply by much when quantity falls. Consequently, most of the incidence of the tax will be borne by producers (and vice-versa if supply is elastic and demand is inelastic):

$$\frac{\varepsilon_s}{\varepsilon_s - \varepsilon_d} = \frac{0.5}{0.5 - (-3)} = \frac{1}{7}.$$

- Similarly, if demand and supply are equally elastic ($\varepsilon_d = \varepsilon_s = 2$), then the incidence is borne equally by consumers and producers, $\frac{\varepsilon_s}{\varepsilon_s - \varepsilon_d} = 0.5$.



The figure above illustrates a perfectly inelastic supply curve. Notice that a price drop or increase would not change the quantity supplied. The prices received by suppliers would fall by τ.

Can you draw the case where the supply is perfectly elastic and demand is downward sloping? What about the symmetric cases where demand is perfectly inelastic or perfectly elastic by supply is upward sloping?

3 Deadweight Loss

- Notice that the tax *increases* the price charged to consumers and *decreases* the price received by producers. In the absense of the tax, some producers would be selling the goods to consumers who are willing to pay for them. Therefore, taxes reduce overall quantities, and result in deadweight loss.

- In the first two figures above, the deadweight loss is given by the area of the blue triangles. The blue vertical lines represent the producers that would be willing to sell to consumers and the dollar values of these lost transactions.

- What affects the deadweight loss? Suppose the producers were perfectly elastic, ε_s large! The tax would be borne by the consumers ($p^*_\tau = p_0$) and the equilibrium quantity would fall by $\frac{\tau}{p_0}\varepsilon_d$ percent. Notice that if consumers are inelastic, ε_d small, then the quantity does not change a lot. Almost all the consumers that previously received the good, still receive it. Therefore, the deadweight loss is small.

- A symmetric argument holds for perfectly elastic consumers, but inelastic producers. Intuitively, the change in quantity is small if either the consumers or producers are inelastic. Hence, the deadweight loss is small for a given size of the tax if the elasticities are small.

- This point can be illustrated by figure above with a perfectly inelastic supply curve. The equilibrium quantity does not change after the tax is imposed, and the deadweight loss triangle has zero area.

- Returning to our mathematical example above, we want to calculate the change in quantity supplied when a tax of τ is levied on consumers. Let $p^*(\tau)$ be the equilibrium price with a tax of τ. By the chain rule, the percent change in quantity supplied is

$$\begin{aligned}
\frac{S_x(p^*(\tau)) - S_x(p_0)}{S_x(p_0)} &\approx \frac{1}{S_x(p_0)}\frac{\partial S_x(p^*(\tau))}{\partial p}\frac{\partial p^*(\tau)}{\partial \tau}\tau \\
&= \frac{1}{p_0}\varepsilon_s\frac{\partial p^*(\tau)}{\partial \tau}\tau
\end{aligned}$$

- The expression in equation 1, allows us to approximate the price change:

$$\frac{\partial p^*(\tau)}{\partial \tau}\tau \approx p^*(\tau) - p_0 = \tau\frac{\varepsilon_d}{\varepsilon_s - \varepsilon_d}.$$

  Therefore, we get

$$\begin{aligned}
\frac{S_x(p^*(\tau)) - S_x(p_0)}{S_x(p_0)} &\approx \frac{\tau}{p_0}\frac{\varepsilon_s\varepsilon_d}{\varepsilon_s - \varepsilon_d} \\
&= \frac{\tau}{p_0}\frac{1}{\frac{1}{\varepsilon_d} - \frac{1}{\varepsilon_s}}.
\end{aligned}$$

  Since the market clears, the percent change in demand must also be identical.

- The expression above is intuitive. The change in quantities is small if either the tax is small, or if the demand or supply is inelastic ($\frac{1}{\varepsilon_d}$ or $\frac{1}{\varepsilon_s}$ is large). The deadweight loss is also small if the quantities transacted in equilibrium do not change substantially.

4 Tax Salience: Chetty, Looney and Kroft

4.1 Motivation

- What is the sales tax rate in Massachusetts? Do you focus on the after-tax or pre-tax price when shopping? If consumers are unaware of tax rates or base their decisions on the pre-tax price, then they may be insensitive to taxes relative to prices. This phenomenon can make consumers less elastic. As we saw earlier, inelastic consumers would bear the burden of the taxes, but taxes would cause lower reductions in deadweight loss.

- Let us say that the demand consumers express depends on the tax and the price. $x(p, \tau)$ is the demand at price p and a percent tax τ.
- If consumers fully account for the tax when making decisions, a tax-inclusive price of $p(1+\tau)$ and a tax of zero results in the same quantity demanded as a price of p and a tax of τ. So, $x(p, \tau) = x(p(1+\tau), 0)$. This is not true if consumers do not fully account for the tax.
- How much does quantity change when the tax increases by 1%? If consumers fully account for the tax,

$$
\begin{aligned}
\varepsilon_{x,p} &= -\frac{p}{x(p,\tau)} \frac{\partial x(p,\tau)}{\partial p} \\
&= -\frac{p(1+\tau)}{x(p,\tau)} \frac{\partial x(p(1+\tau),0)}{\partial p} \\
&= -\frac{p(1+\tau)}{x(p(1+\tau),0)} \frac{\partial x(p(1+\tau),0)}{\partial (1+\tau)} \\
&= \varepsilon_{x,1+\tau}.
\end{aligned}
$$

If consumers don't fully account for the tax, we expect that $\varepsilon_{x,p} > \varepsilon_{x,1+\tau}$.

4.2 Empirical Strategy

- Chetty, Looney and Kroft analyze this question in two ways. First, they conduct an experiment in a grocery store chain to assess whether consumers reduce demand to a greater degree when the price-tags indicate the after-tax prices. Second, they assess if alcohol consumption is more sensitive to excise tax (which is included in the price tag) to sales tax (which is not included in the price tag).
- Experimental Design: Select products from a large grocery store chain in Northern California where the sales tax rate is 7.375%.
  - Treatment group: experimental pre-tags with post-tax prices in small revenue "impluse purchase" categories.
  - Two Control groups: other products in the same isle, and same products at other stores.

We expect the treatment and control to be identical if individuals fully account for the post-tax price even when the post-tax price is not listed.

- Quasi-experimental Design: Differences in differences estimates for alcohol purchases. Final price of alcohol is
$$p(1+\tau^E)(1+\tau^S),$$
where τ^E is the excise tax and τ^S is the sales tax. The posted price is $p(1+\tau^E)$ and τ^S is levied at the register. Compare the sensitivity to excise and sales taxes by using changes in excise and sales tax rates *within* states.

- Why do both? Experimental design may suffer from "Hawthrone effect." It is based on the idea that individuals may change their behavior because they suspect that they are being observed. Specifically, the post-tax price-tag may strike people as strange, and they may avoid purchasing those products.

4.3 Results

- Experimental design shows that quantity sold in treatment categories fell by 1.3 units, but quantities increased in control categories by 0.84 units. Within-store treatment is $DD_{TS} = -2.14$.

- For DD_{TS} to be a valid causal effect, the trends for treated and control product groups should be identical. To assess this, the authors calculate the difference in differences for control stores (i.e. stores with no intervention). The difference in quantities sold in the treated and control product categories changed by 0.06, and the estimate is not statistically significant. Consistent with common trends.

- Finally, the triple-difference, which controls for within-store and within-product trends also results in a fall of 2.20 units for the products with post-tax price tags.

- The estimates suggest that a 10% tax increase is identical to a 3.5% price increase because the tax increase is not as salient as a price increase.

- Quasi-experimental evidence also consistent with salience effects. Elasticity with respect to excise tax $\varepsilon_{x,1+\tau^E} = 0.88$, while the elasticity with respect to sales tax changes is lower, at $\varepsilon_{x,1+\tau^S} = 0.20$.

4.4 Consequences

- If consumers are inattentive to sales tax, they are more likely to bear a great share of the tax burden. This is a consquence of their demand being relatively inelastic to sales taxes as compared to prices.

- Excise taxes and sales taxes have different effects, unlike the classical model of fully optimizing consumer.

- Others?