ECON 180

Introduction to Principles of Microeconomics and Financial Project Evaluation

Lecture 19: Tax Incidence & Elasticity

October 20, 2021

Version 1

Required Reading and Viewing

- Topics 4.1, 4.2 & 4.3 in Hutchinson, E. (n.d.). *Principles of Microeconomics*. https://pressbooks.bccampus.ca/uvicecon103/
- Topic 4.1: Calculating Elasticity: https://pressbooks.bccampus.ca/uvicecon103/chapter/4-2-elasticity/
- Topic 4.2: Elasticity and Revenue: https://pressbooks.bccampus.ca/uvicecon103/chapter/4-4-elasticity-and-revenue/
- Topic 4.3: Relative Elasticity: https://pressbooks.bccampus.ca/uvicecon103/chapter/4-3-calculating-elasticity/

Recommended Reading

- Stand-Up Economics: Chapters 12 and 14
- Stand-Up Microeconomics: http://standupeconomist.com/stand-up-economics-the-micro-textbook/ (Choose the version with calculus.)
  - **The above has plenty of *solved problems* for you to learn from.**
- Tax incidence [Web Page]. (n.d.). Retrieved from http://www.amosweb.com/cgi-bin/awb_nav.pl?s=wpd&c=dsp&k=tax+incidence
  - **A simple explanation of tax incidence, with mildly interactive graphics**

Elasticity Case Studies I

- Albadi, M. H. & El-Saadany, E.F. (2008). A summary of demand response in electricity markets. *Electric Power Systems Research*, *78*(11), 1989-1996. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.epsr.2008.04.002
- Andruszkiewicz, J., Lorenc, J. & Weychan, A. (2020). Seasonal variability of price elasticity of demand of households using zonal tariffs and its impact on hourly load of the power system. *Energy, 196*, 117175. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.energy.2020.117175
- Corrigan, J. R. et al. (2021). Estimating the price elasticity of demand for JUUL E-cigarettes among teens. *Drug and Alcohol Dependence*, *218*, 108406. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.drugalcdep.2020.108406
- Davidson, B. & Hellegers, P. (2011). Estimating the own-price elasticity of demand for irrigation water in the Musi catchment of India. *Journal of Hydrology, 408*, 226-234. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.jhydrol.2011.07.044
- Dornburg, V., Faaij, A., Patel, M. & Turkenburg, W. C. (2006). Economics and GHG emission reduction of a PLA bio-refinery system—Combining bottom-up analysis with price elasticity effects. *Resources, Conservation and Recycling, 46*, 377-409. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.resconrec.2005.08.006
- Fan, S. & Hyndman, R. J. (2011). The price elasticity of electricity demand in South Australia. *Energy Policy*, *39*(6), 3709-3719. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.enpol.2011.03.080

Elasticity Case Studies II

- Feehan, J. P. (2018). The long-run price elasticity of residential demand for electricity: Results from a natural experiment. *Utilities Policy, 51*, 12-17. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.jup.2018.02.003
- Galvin, R. & Sunikka-Blank, M. (2012). Including fuel price elasticity of demand in net present value and payback time calculations of thermal retrofits: Case study of German dwellings. *Energy and Buildings*, *50*, 199-228. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.enbuild.2012.03.043
- Madison, C. F. & Roberts, G. (2018). Price Elasticity of Supply and Productivity: An Analysis of Natural Gas Wells in Wyoming. *The Energy Journal*, *39*(S1), 79-100. http://dx.doi.org.ezproxy.library.uvic.ca/10.5547/01956574.39.SI1.cmas
- Noone, B. M. & Cachia, G. (2020). Menu engineering re-engineered: Accounting for menu item substitutes in pricing and menu placement decisions. *International Journal of Hospitality Management*, *87*, 102504. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.ijhm.2020.102504
- Olmstead, T. A. et al. (2015). The price elasticity of demand for heroin: Matched longitudinal and experimental evidence. *Journal of Health Economics, 41*, 59-71. https://doi-org.ezproxy.library.uvic.ca/10.1016/j.jhealeco.2015.01.008

Learning objectives

- Understand the concept of tax/cost incidence/burden.
- Understand that incidence is independent of who pays the tax.
- Understand how incidence depends on the elasticities of supply and demand.
- Be able to use a supply and demand diagram to derive tax incidence.
- Be able to use algebra to calculate tax incidence.
- Be able to use elasticities and calculus to calculate tax incidence.

Relevant Solved Problems

- From Stand-Up Economics: http://standupeconomist.com/stand-up-economics-the-micro-textbook/ (Choose the version with calculus.)
- Burdens: 12.2(b), 12.3(f), 12.8, 14.3(e), 14.5(c)
- Elasticities: 14.2, 14.4, 14.5(a)(b)
- Calculating Elasticities: 12.9(b)(c), 14.3(a)

New Equations

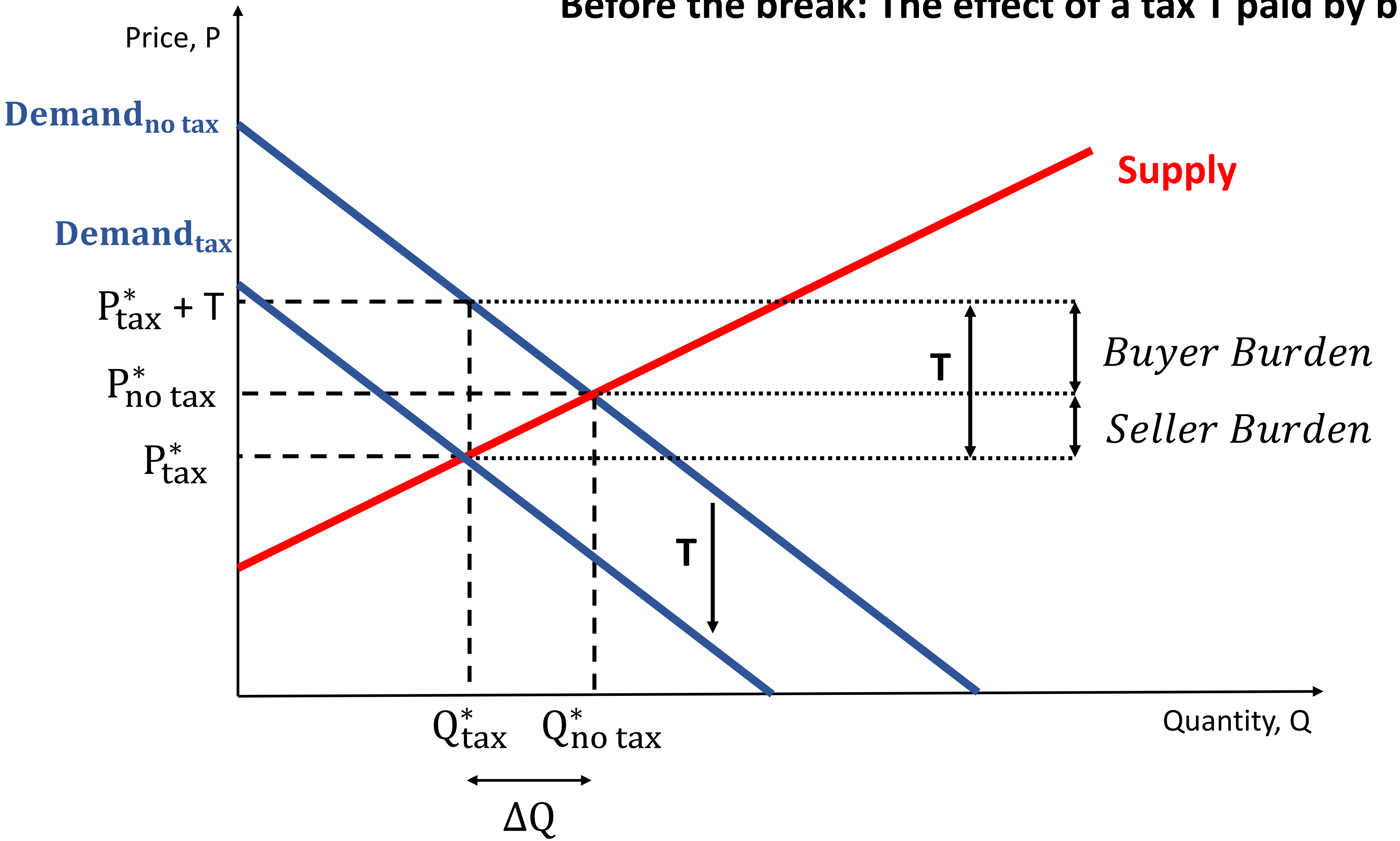
$f(x)$

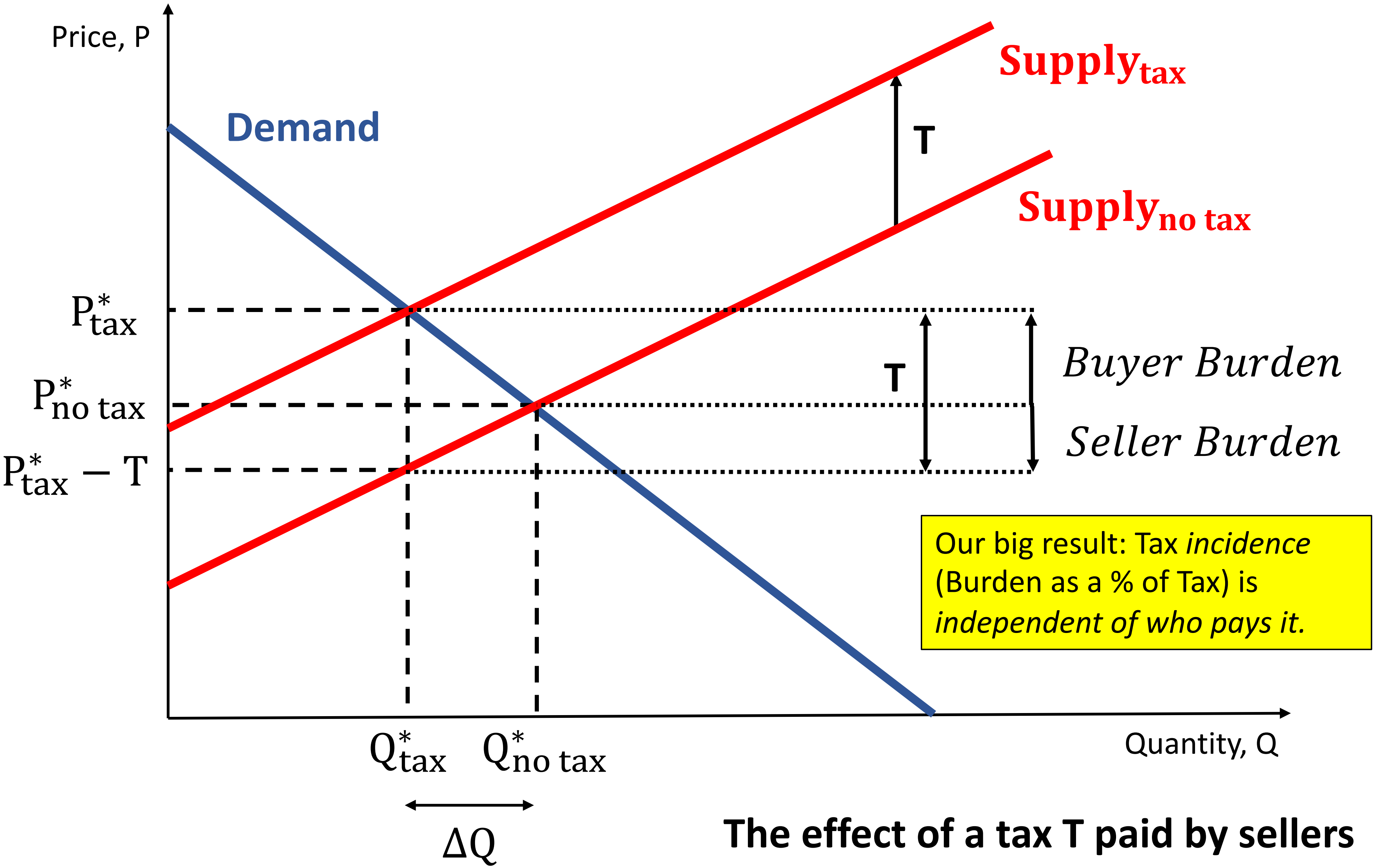
- Notation: The orange symbol on a slide indicates a formula sheet formula is introduced there.

- $\text{Price Elasticity of (S, D)} = \dfrac{\text{\% change in Quantity (sup.,dem.)}}{\text{\% change in Price}}$
- $\varepsilon = \dfrac{dQ_d(P)}{dP}\dfrac{P}{Q}$
- $\text{Buyer's Burden} = \dfrac{\eta}{\eta - \varepsilon}$

ESSENTIALS (17 slides)

Before the break: The effect of a tax T paid by buyers



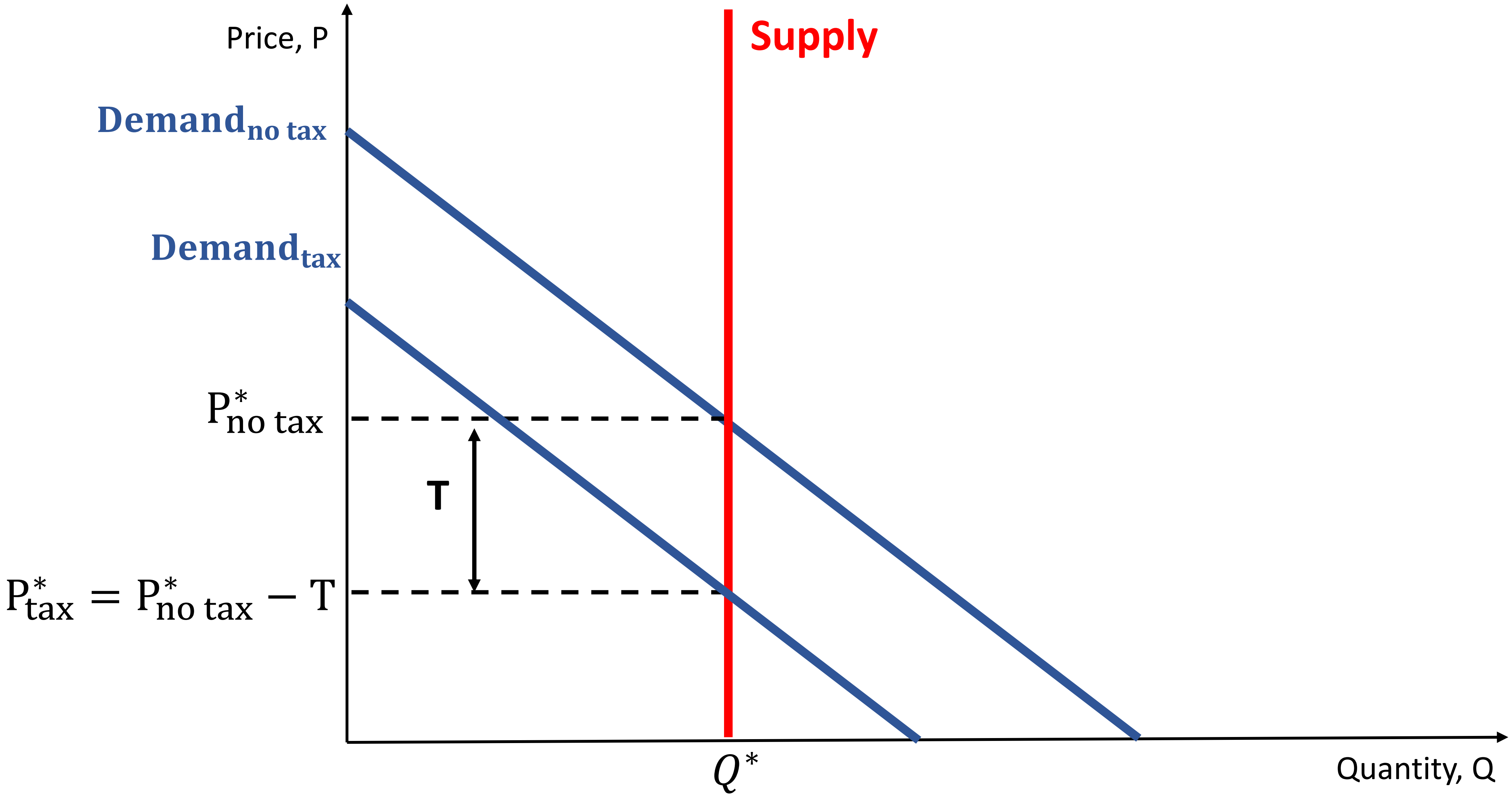


Our big result: Tax *incidence* (Burden as a % of Tax) is *independent of who pays it.*

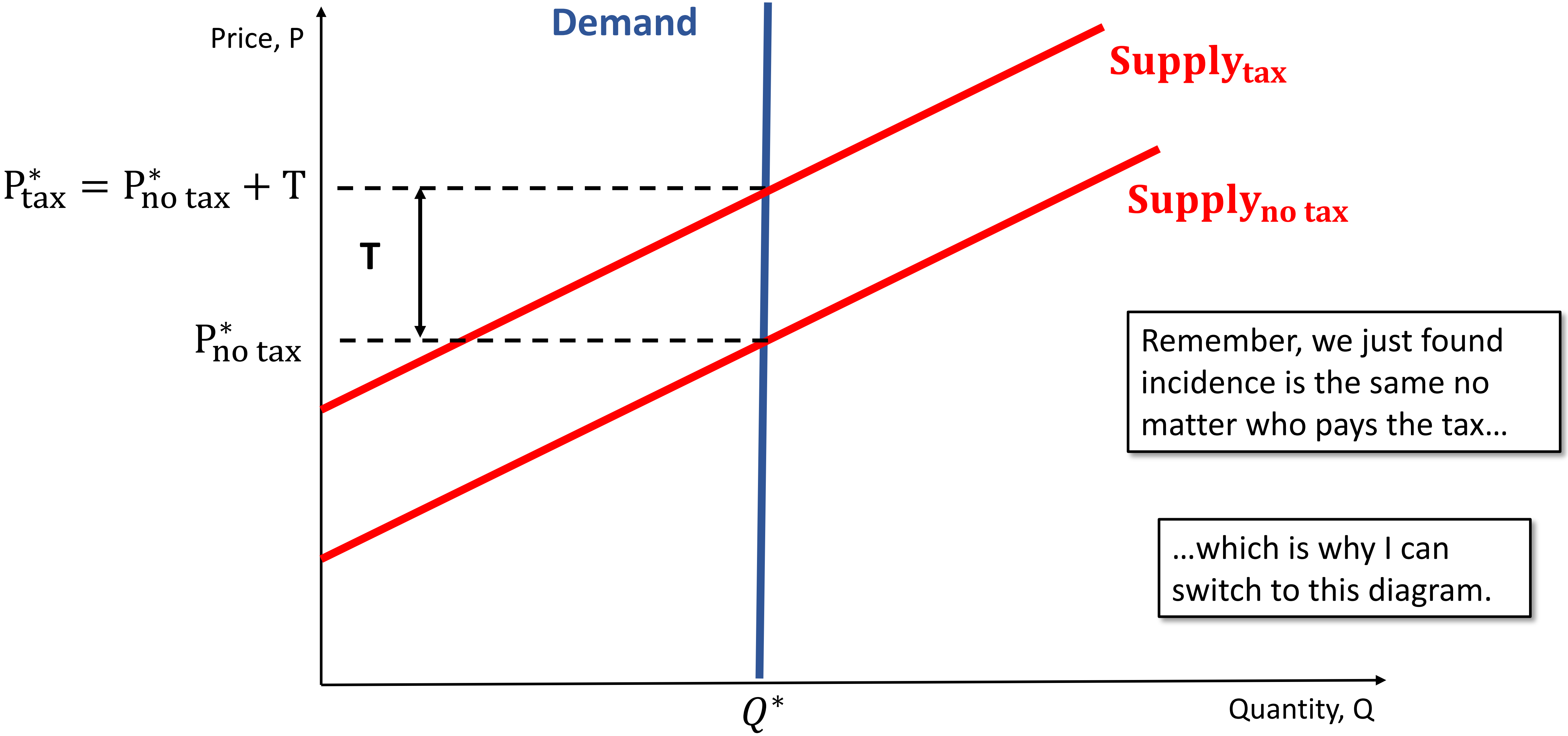
The effect of a tax T paid by sellers

How useful is this?

- We solved for the burden of taxation algebraically.
- This required equations for supply and demand.
- Problem: in real life, we almost never have neat equations for supply and demand!
- These measure willingness to pay/produce, and we (usually) only observe what is actually bought/produced.
- We *can* get pretty good estimates of P* and Q*, though…
- ...and we can often estimate how much quantity supplied/demanded would change if we raised prices just a tiny bit.
- Is there a way of using these to figure out how much more (or less) a seller’s burden is than a buyer’s?
- Given that I just asked that question, you can probably guess the answer.
- Let’s develop some quick intuition before seeing how it’s done (spoilers: it’s with calculus).



If Supply is 'Stuck', sellers' burden = 100% of the tax



If Demand is 'Stuck', buyers' burden = 100% of the tax

Elasticity (or what we meant by, ‘stuck’)

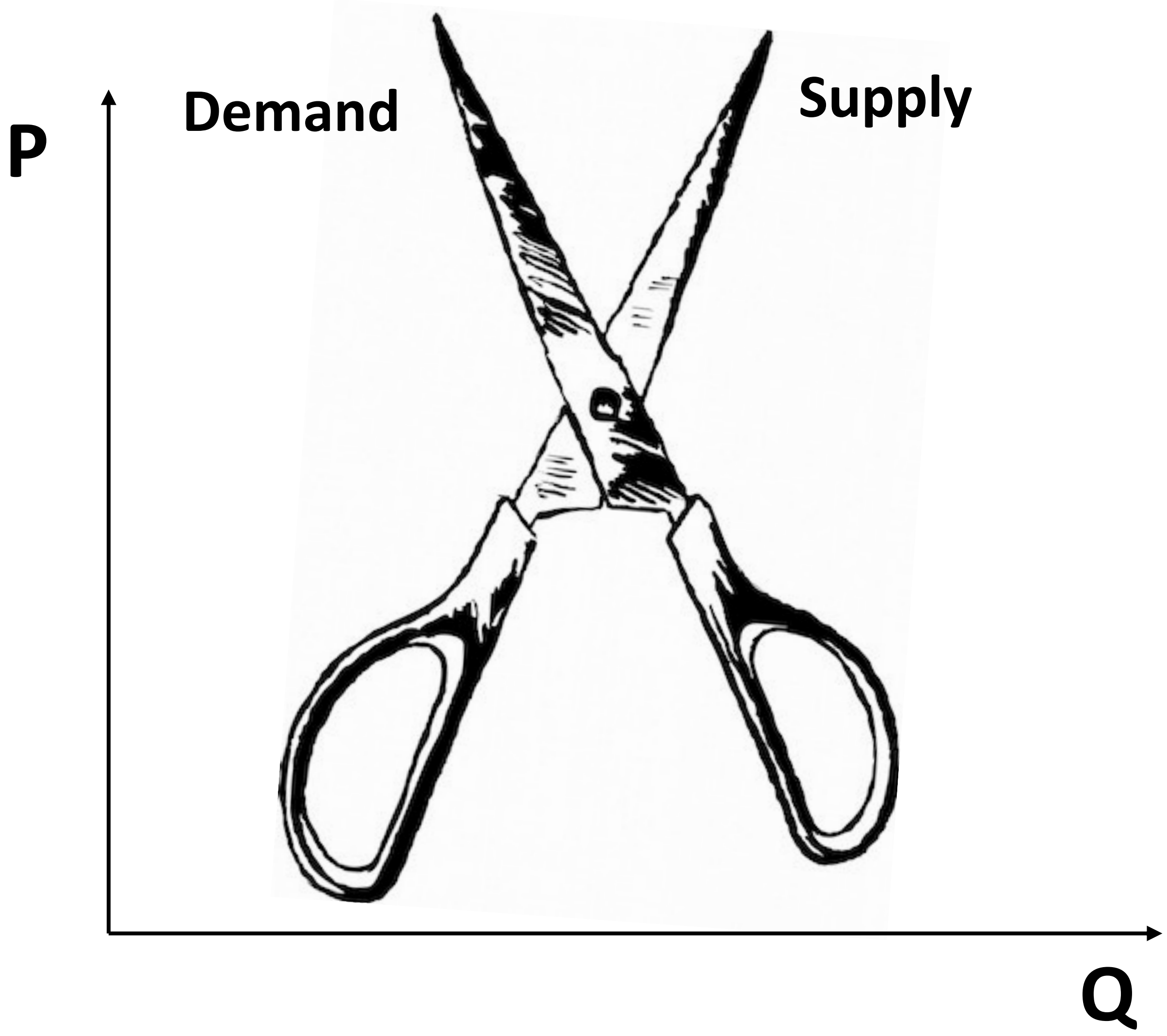
$f(x)$

- Economists have found it’s very useful to have a measure of how responsive supply/demand is to a change in prices. (You’re about to see one reason why.)
- For the measure to be broadly applicable, it should be unitless.
- What we’ve come up with:
- $\text{Price Elasticity of (S, D)} = \dfrac{\text{\% change in Quantity (sup.,dem.)}}{\text{\% change in Price}}$
- ’Elasticity’ because it measures ‘stretchiness’ in response to price.
- Elasticity = 0 → ‘stuck’ vertically, as in diagrams above.
- As elasticity rises, Supply and Demand become more horizontal.
- **The required readings are *crucial* to understanding elasticity – you may wish to try the (easy) optional readings, too!**

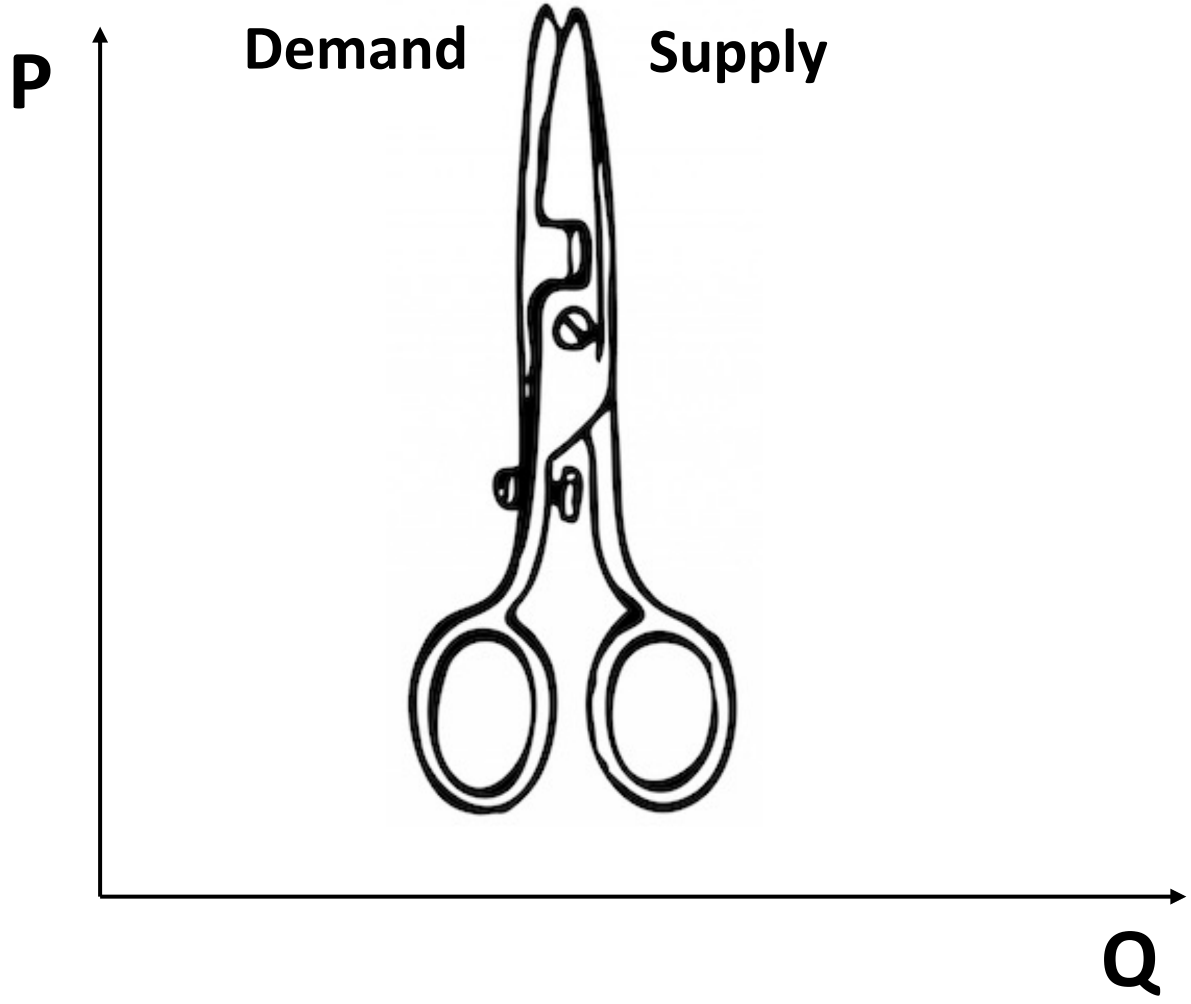
Some Terminology

- Price elasticity of demand, ε , is never positive: a 1% increase in price will always lead to a fall (% change < 0) in quantity demanded.
- (For our purposes) Price elasticity of supply, η, is never negative: a 1% increase in price will not decrease quantity supplied.
- Supply or demand is called *inelastic* if the absolute value of the relevant price elasticity is less than 1: a 1% rise in price will lead to less than a 1% change in quantity supplied or demanded.
- (If demand is inelastic, that's a good time for firms to raise prices! See the recent epi-Pen scandal.)
- Supply or demand is *elastic* if the absolute value of the relevant elasticity is greater than 1: a 1% rise in price leads to more than a 1% change in quantity supplied or demanded.

The Scissors Intuition (for linear functions)



Supply and Demand are Elastic



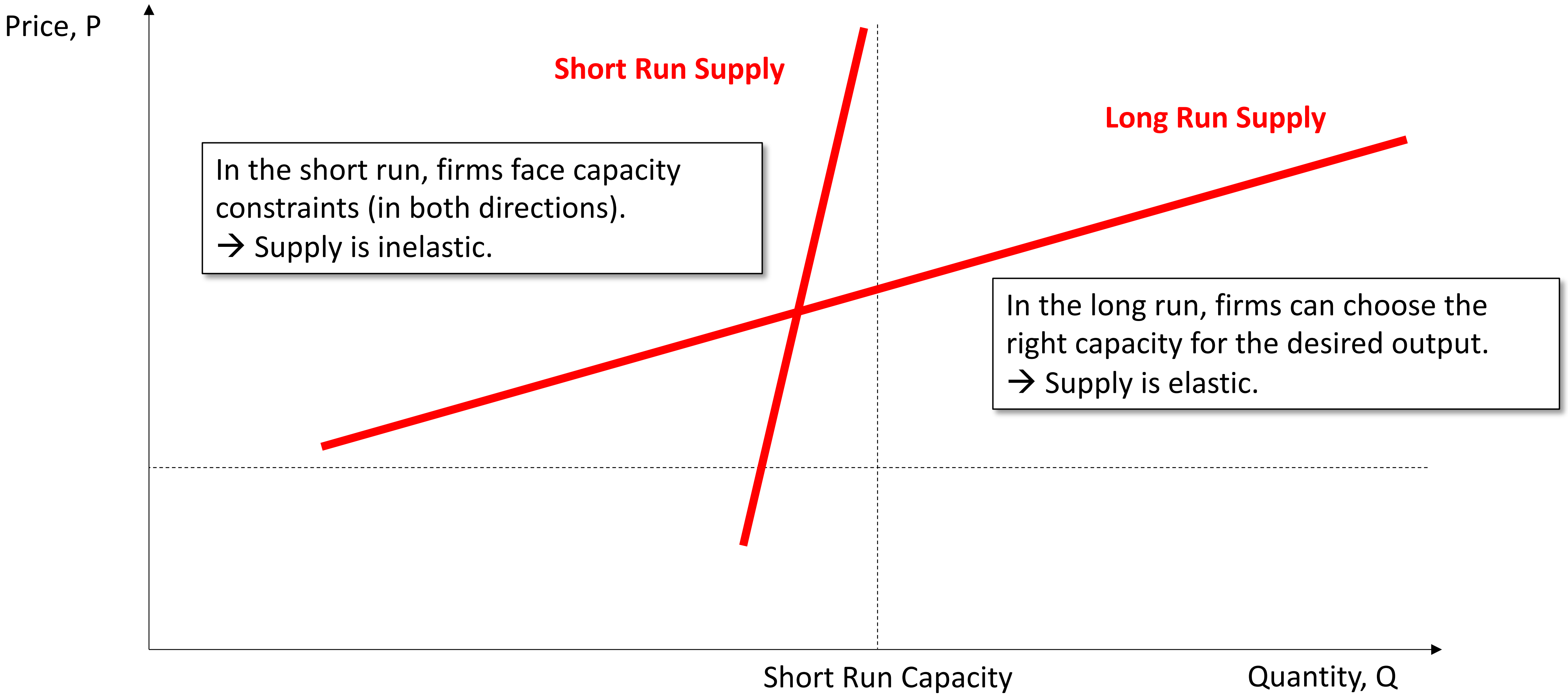
Supply and Demand are Inelastic

Price Elasticity of Demand and Revenue

- It’s very important for any company to know whether the demand it faces is elastic or inelastic.
- Revenue = Price x Quantity
- If demand is inelastic, a 1% rise in price will lead to less than a 1% fall in quantity demanded → raising prices will *raise* revenue.
- If demand is elastic, a 1% rise in price will lead to more than a 1% fall in quantity demanded → raising prices will *lower* revenue.

What affects price elasticity of demand?

- If there are adequate substitutes for a product, demand will tend to be *elastic*: raise prices, and you'll scare consumers away to a substitute.
- If a good is a necessity, demand will be *inelastic*. If the price of insulin goes up, diabetics are going to continue to buy it, no matter what.
- If a good is a major expense relative to income, demand will tend to be more *elastic*. Consumers shop around for big purchases.
- In the long run, demand tends to be more elastic than in the short run. Suppose the price of gas goes up in a town with no public transit. In the short run, car owners are stuck. In the long run, they can buy a more efficient car.
- Economist talk: in the **short run**, many things are stuck in place, or *fixed*. In the **long run**, everything can change.
- This also affects price elasticity of supply, η.


Price, P
Short Run Supply
Long Run Supply
In the short run, firms face capacity constraints (in both directions).
→ Supply is inelastic.
In the long run, firms can choose the right capacity for the desired output.
→ Supply is elastic.
Short Run Capacity
Quantity, Q

So, elasticity is the key, huh?

- The more *inelastic* supply/demand is, the greater the burden on sellers/buyers.
- For linear supply/demand, check which scissor blade is the most open: that’s who has the least burden.
- It’s like a reverse game of ‘chicken’: whoever is least able to ‘flinch’ (react to price changes) loses.
- Let’s see if we can get something a bit more formal.
- We’ll begin by looking closely at the calculus definitions of price elasticity of demand, ε, and price elasticity of supply, η.
- (Economists like Greek letters almost as much as physicists.)

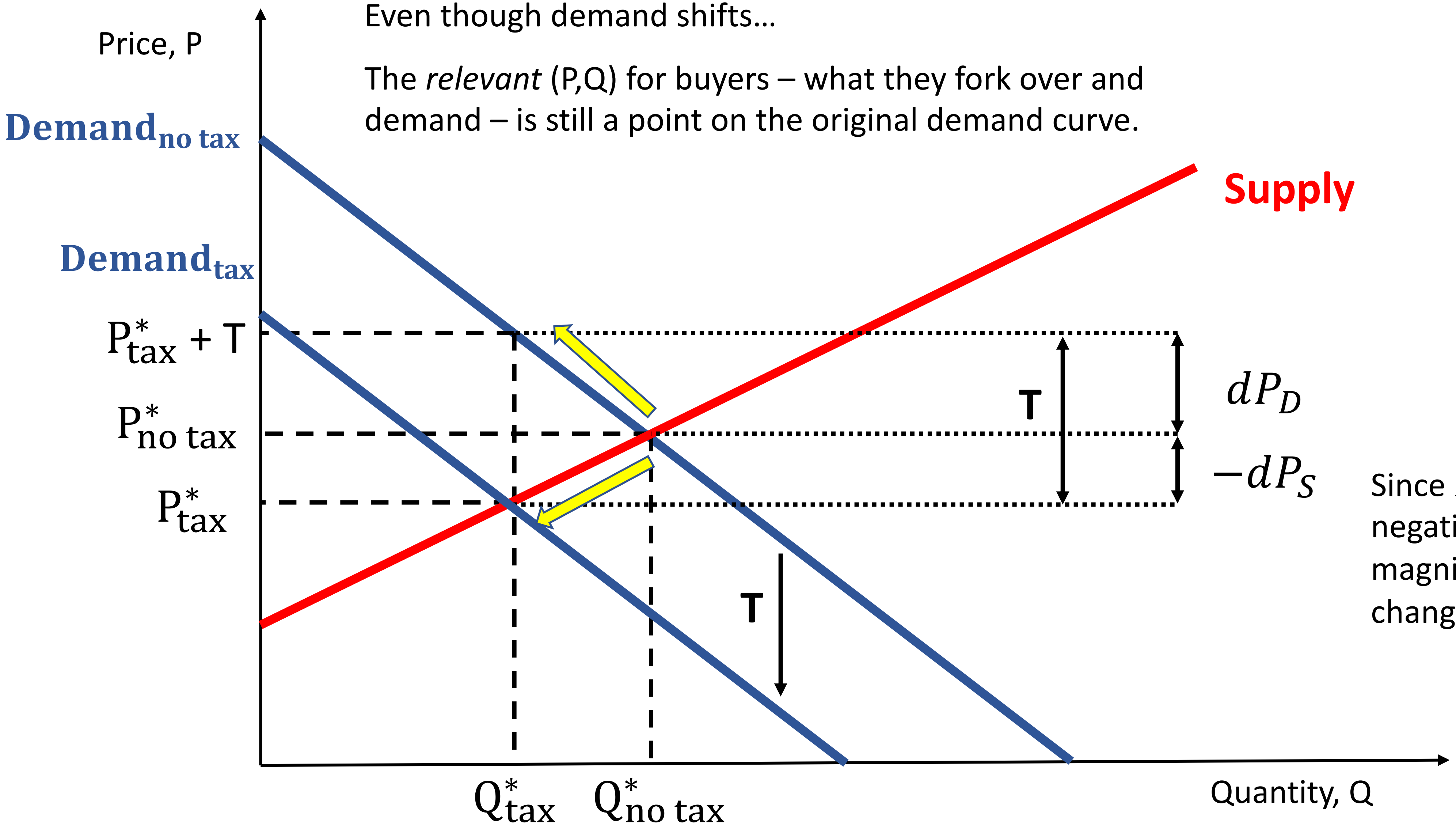
Price elasticity for tiny changes

$f(x)$

- % Change in Quantity = Change in Quantity / Value of Quantity
- → % Change in Quantity = dQ / Q
- % Change in Price = Change in P / Value of P = dP / P
- Price Elasticity = % Change in Q / % Change in P
- → Price Elasticity = $\frac{dQ}{Q}\frac{P}{dP} = \frac{dQ}{dP}\frac{P}{Q}$
- $\varepsilon = \frac{dQ_D(P)}{dP_D}\frac{P_D}{Q_D}$ and $\eta = \frac{dQ_S(P)}{dP_S}\frac{P_S}{Q_S}$
- (Normally, we wouldn't bother putting the S or D on the P and Q, but in this case it'll save confusion later on.)

Even though demand shifts…

The *relevant* (P,Q) for buyers – what they fork over and demand – is still a point on the original demand curve.



$$dQ_D = dQ_S = dQ$$

Since P_S falls (changes negatively), the magnitude of the changes is $-dP_S$

Revisiting an old friend…

<u>Teeny tiny taxes</u>: when T = dP_D - dP_S

- Burden on buyers = $\frac{dP_D}{\mathrm{T}}$
- Burden on sellers = $-\frac{dP_S}{T}$
- $\frac{Buyers'Burden}{Sellers'Burden} = -\frac{dP_D}{dP_S} = -\frac{\eta}{\varepsilon}$
- No, really! Starting from the pre-tax equilibrium:
- $-\frac{\eta}{\varepsilon} = -\frac{dQ}{dP_S}\frac{P*}{Q*} \times \frac{dP_D}{dQ}\frac{Q*}{P*} = -\frac{dP_D}{dP_S}$
- (The dQs cancel out because the change in Q is the same for supply and demand.)

The buyers' burden in terms of elasticities

- We want $\frac{dP_D}{\mathrm{T}}$. We know $T = dP_D - dP_S$ and $\frac{dP_D}{dP_S} = \frac{\eta}{\varepsilon}$
- →$T = \left(\frac{\eta}{\varepsilon} - 1\right) dP_S$, so $dP_S = \frac{T}{\left(\frac{\eta}{\varepsilon} - 1\right)}$
- →$T = dP_D - \frac{T}{\left(\frac{\eta}{\varepsilon} - 1\right)}$
- →Buyers' burden = $\frac{dP_D}{\mathrm{T}} = 1 + \frac{1}{\left(\frac{\eta}{\varepsilon} - 1\right)} = \frac{\eta}{\eta - \varepsilon}$
- →Sellers' burden = $-\frac{\varepsilon}{\eta - \varepsilon}$

This should make intuitive sense…

- The burden on buyers is the seller's share of the total magnitude of elasticities.
- If sellers are totally inelastic (η = 0), they absorb all the tax.
- If buyers and sellers are equally elastic, they share the burden equally.
- If buyers are more elastic than sellers, they bear less than half the burden.
- If buyers are less elastic than sellers, they bear more than half the burden.
- If buyers are totally inelastic (ε=0), they bear 100% of the burden.
- (Think of diabetics and a tax on insulin…)

AFTER HOURS

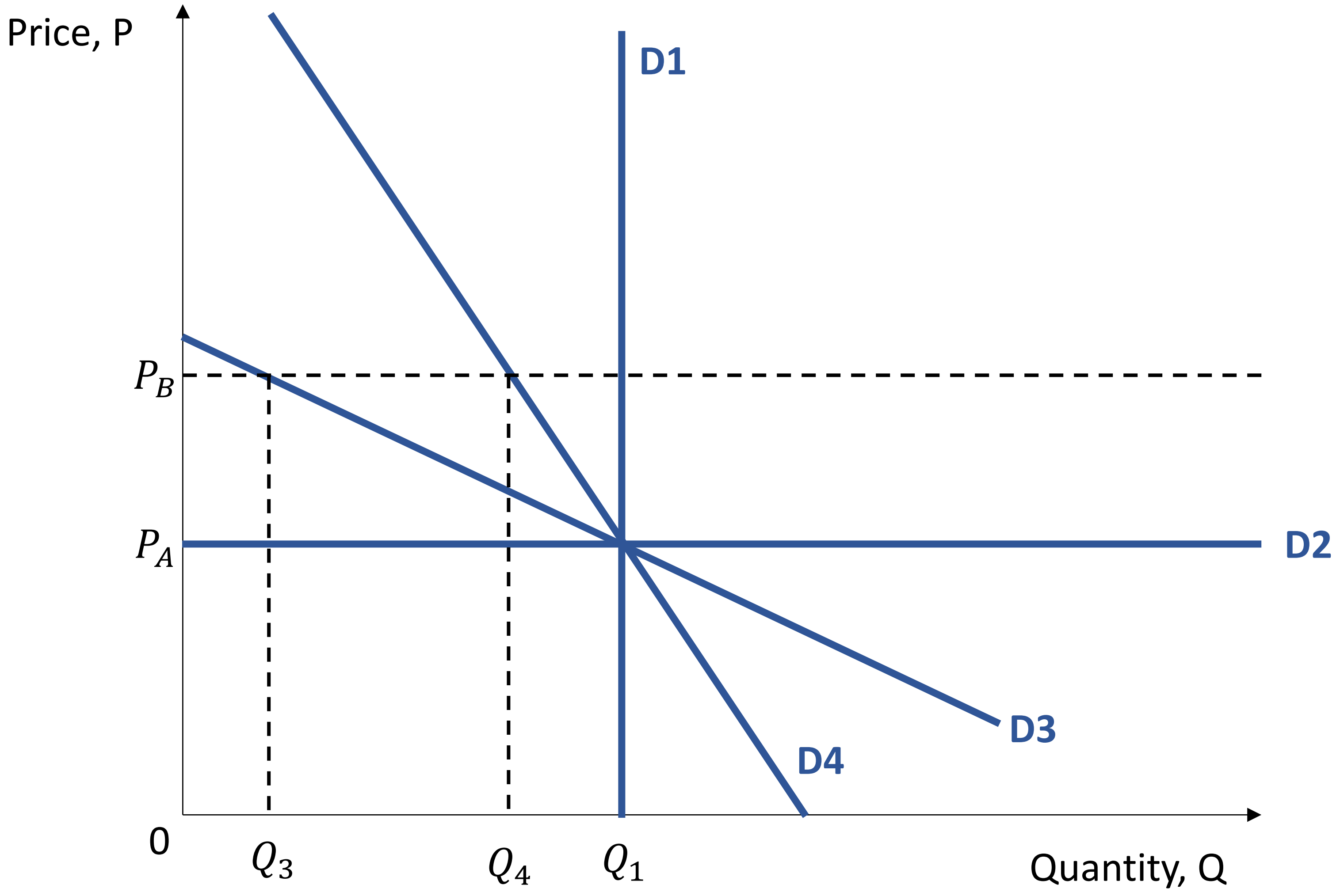
- A worked-through numerical example (2 slides)
- Demand curves with different elasticities (1 slide)
- What about other types of taxes? (1 slide)
- More intuition on why this is useful (1 slide)

A numerical example

- Consider our first example from the last lecture.
- Before tax (last lecture, Slide 22):
- $\mathrm{Q_d} = 11{,}025 - 735\mathrm{P}$
- $\mathrm{Q_s} = -9{,}780 + 1956\mathrm{P}$
- When we solved for the before tax equilibrium, we found
- P* = 7.7, Q* = 5,342.5
- Suppose that, starting from this equilibrium, a tiny tax T is charged.
- What % of the burden is felt by consumers, and what % by producers?

Putting together the buyer's burden

- $Q_d = 11{,}025 - 735P, Q_s = -9{,}780 + 1956P$
- P* = 7.7, Q* = 5,342.5
- Price elasticity of supply:
- $\eta = \frac{dQ_S}{dP_S}\frac{P*}{Q*} = (1956)\times\frac{7.7}{5{,}342.5} = 2.82$
- Price elasticity of demand:
- $\varepsilon = \frac{dQ_D}{dP_D}\frac{P*}{Q*} = (-735)\times\frac{7.7}{5{,}342.5} = -1.06$
- $\eta - \varepsilon = 2.82 + 1.06 = 3.88$
- Buyer's burden = $\frac{\eta}{\eta-\varepsilon} = \frac{2.82}{3.88} = 73\%$, as before.
- →Seller's burden = 100% - 73% = 27%, as before.



Demand Curves with Different Elasticities

The diagram has been rigged so that at price P_A, quantity demanded is the same for all demand curves.

When considering the shift from P_A to P_B, this will allow us to easily translate changes in quantity demanded into relative price elasticities of demand.

(Since a greater fall in quantity demanded translates to a greater % change from the initial, common quantity demanded.)

We see that D2 is most elastic, then D3, then D4, and then D1.

D2 is perfectly elastic.

D1 is perfectly inelastic.

What about non-linear functions? Sales taxes?

- It's common to see taxes not as $T per unit, but as t% of the price of a unit (e.g. sales taxes).
- While beyond the scope of this introductory course, our results still hold for these *ad valorem* taxes: it doesn't matter who pays the tax, and the least elastic party ends up shouldering most of the burden.
- We've worked through a case where demand and supply are linear, but the intuitions we derived hold for more general functions, as well.
- If you understand what influences price elasticity of demand and supply, and what their relative magnitudes are, you can predict who'll end up paying for most of a tax or other cost increase.
- This can be very useful!
- You can also deal with *subsidies* or cost decreases, by treating them as negative taxes.

What’s the damage?

- Suppose due to climate change, fishing becomes more expensive. How much of the extra cost is passed on to consumers?
- A change in exploration tax credits means that the tax on a metal your firm uses as an input has gone up. How much of the tax will the mining firm absorb, and how much more will you end up paying per ton?
- The price of gasoline is expected to fall. Does this mean your company should expect lower shipping costs? If so, by how much?
- We developed our incidence tool in the context of taxation, but it applies to all of the above.