Transport supply

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We have discussed how demand changes in response to the cost of travel, but we have generally considered the supply of transportation infrastructure or service to by dependent on forces outside the market. This is often the case, but in some circumstances, supply may be responsive to demand and price.

Supply curves

As we have previously discussed, demand curves are downward-sloping, so people are willing to consume more of a good or service when prices are lower.

Supply curves slope upward, like the one shown in Figure 1. When the revenue from providing a service increases, more firms will be willing to provide more of that service.

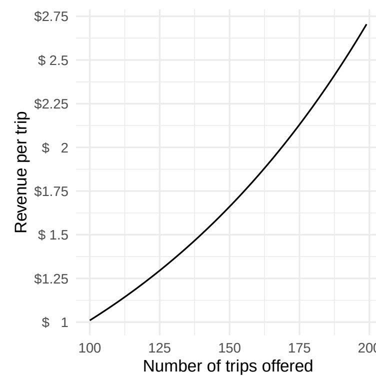

Figure 1: Example of a demand curve

Elasticity

The *price elasticity of supply* refers to the steepness of the supply curve or how responsive firms are to changes in the revenue per unit provided.

We can calculate the price elasticity of supply similarly to how we've calculated the price elasticity of demand.

First, we would calculate the symmetrical percent change in both price (revenue per unit offered) and supply (number of units offered). Remember that symmetrical percent change is:

$$\frac{x_2 - x_1}{\frac{1}{2}(x_2 + x_1)}$$

And the elasticity would be the percent change in supply divided by the percent change in price.

Mohring Effect

Demand elasticities are most relevant when service providers are profit-maximizing, but the cost of operating a service can also influence supply even when the provider is trying to make socially-optimal choices.

Specific to public transit, the economist Herbert Mohring developed the following equation to describe to optimal frequency of bus service that minimizes both the cost of providing the service and the cost of using the service:

$$F = \sqrt{\frac{Vp}{2CT}}$$

Where:

- F = the frequency of the service (vehicles per hour)
- V = the value of passenger travel time (dollars per hour)
- p = ridership on a route (riders per hour)
- C = the cost of operating the service (dollars per vehicle-hour)
- T = the time it takes to traverse the route (hours per vehicle)

Let's say there is a a bus route that currently costs /$200 per vehicle-hour to run, and each vehicle trip takes a vehicle 2 hours. The value of a rider's time is /$18 per hour. Currently, the bus operates at five-minute headway (so 12 buses arrive at each stop per hour), and the current ridership is 880 passengers per hour.

The transit agency uses Mohring's equation to see if their current frequency is socially optimal (a transit agency probably wouldn't do this in practice, but let's just go with it for this example).

The find that the optimal frequency is:

$$\sqrt{\frac{18 \times 880}{2 \times 200 \times 2}} = 4.4$$

They're offering way too much service! So they reduce their service to approximately 4.4 buses per hour, which corresponds to a 13 minute headway.

However, this changes the cost of travel for passengers, since now they have to wait longer, on average, for a bus. It turns out that the elasticity of demand with respect to wait time is 0.5, meaning that a one-percent increase in wait time will result in a 0.5-percent reduction in demand. With five-minute headways, the average wait time for a bus was 2.5 minutes. Now, with 13-minute headways, the average wait time is 6.5 minutes. This is 160-percent increase in wait time, so it results in an 80-percent decrease in demand. The new demand for this transit route is 176 passengers per hour.

The transit agency decides to check to see if their new frequency is still optimal, given this change in ridership. It isn't the new optimal frequency is:

$$\sqrt{\frac{18 \times 176}{2 \times 200 \times 2}} = 2.0$$

So they reduce the service frequency again, this time to operate only 2 buses per hour (a 30 minute headway).

This reduction in frequency results in a further reduction in ridership, and this vicious cycle of ridership losses and service cuts continues.

Mohring described this dynamic to make the case for transit subsidies.

Let's go back to the original condition with buses at 5-minute headways and a demand of 880 passengers per hour. Now let's say taxpayers will subsidize 85% of operations so that the cost of operating the service is only /$30 per hour.

What would the optimal frequency be?

$$\sqrt{\frac{18 \times 880}{2 \times 30 \times 2}} = 12$$

The subsidy supports keeping frequencies, and thus ridership, at the existing level.