Applied Demand Analysis

AGEC 317: Economic Analysis for Agribusiness Management
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Demand

Quantity demand is the quantity of a good or service that consumers are willing and able to purchase under given economic conditions. An individual's demand of a good is a result of utility maximization.
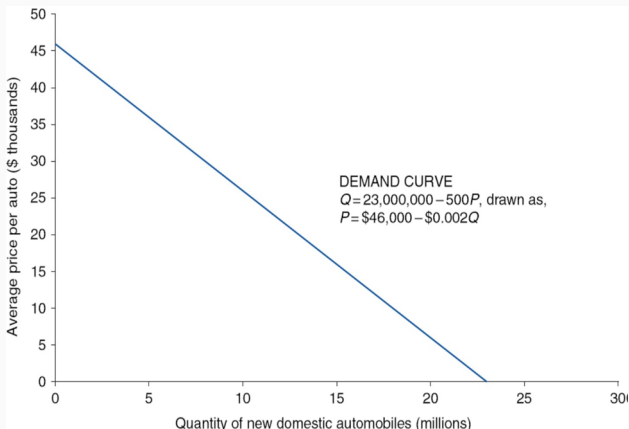
Market demand is the summation of individual demand curves across all consumers in a market.

Factors affecting demand:

- Own-price (on quantity demanded)
- Other goods' prices
- Expectations
- Tastes and preferences
- Many other potential factors

Demand

...but you know all of that. Our job here is to try to *estimate* a demand curve. How do we do that? How would you estimate the demand for cars:

DEMAND CURVE
$Q = 23{,}000{,}000 - 500P$, drawn as,
$P = \$46{,}000 - \$0.002Q$

Demand

Things you would need in an ideal world:

- Lots of variation in price
- Lots of people facing different prices
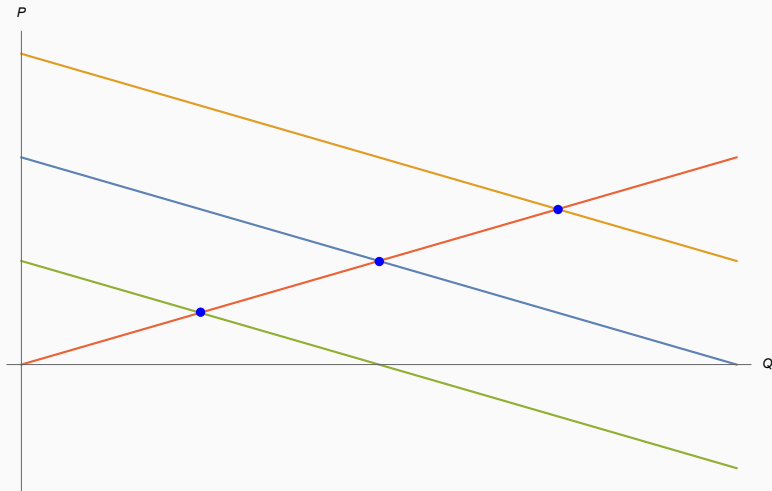- No feedback between price and quantity

Demand

One of the fundamental problems with estimating a demand curve
is that we rarely see customers facing a large variation in prices.
Typically, we observe *market equilibriums*:

Demand curve for lattes			
Price	Jack	Jill	Market
$2.00	17	28	45
$2.50	16	26	42
$3.00	15	24	39
$3.50	14	22	36
$4.00	13	20	33
$4.50	12	18	30
$5.00	11	16	27
$5.50	10	14	24
$6.00	9	12	21
$6.50	8	10	18
$7.00	7	8	15
$7.50	6	6	12
$8.00	5	4	9
$8.50	4	2	6
$9.00	3	0	3

What is the problem with observing these equilibriums?

Demand

It is easy to estimate *supply* when we are trying to estimate demand. Or worse, some weird combination of the two that means nothing. Recall our discussion on bias. If we specify a demand curve as:

$$q_d = \beta_0 + \beta_1 p + \varepsilon$$

We have substantial feedback between q and p, where p affects q, and vice versa. This is known as simultaneity, and is a form of endogeneity.

Demand

Estimating demand is not easy, and requires some complex models beyond the scope of this class:

- Almost-ideal demand system (AIDS) model (Deaton and Muelbauer, 1980)
- Berry, Levinsohn, and Pakes (1993) model
- Instrumental variables and simultaneous equation models (SEMs)

In the real world, you will use one of the above approaches (or something fancier), so I encourage you to keep going with econometrics! To do something right, you often have to get dirty.

For now, we are **going to ignore endogeneity**. We are going to assume it doesn't exist by looking at markets with substantial price variation, and assume that there is no simultaneity.
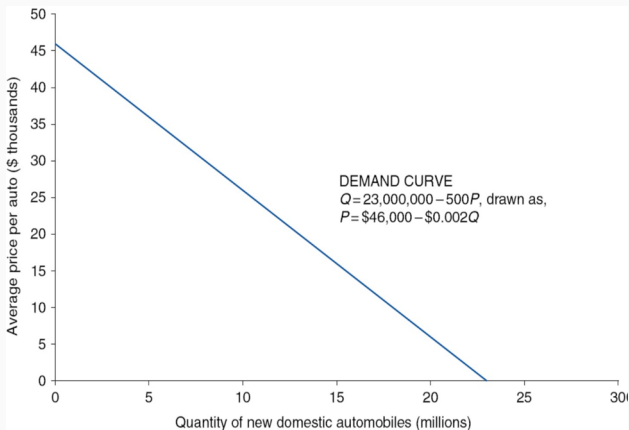
Law of Demand

The law of demand tells us that for normal goods, the demand curve has a negative slope. Why?

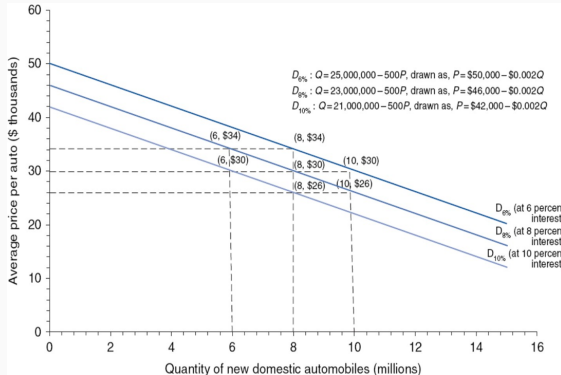We can test the validity of the law of demand with real data.

Demand Curve

Consider the following demand curve for cars. We say the demand curve is $Q = 23,000,000 - 500P$ and inverse demand is $P = 46,000 - 0.002Q$

DEMAND CURVE
$Q = 23,000,000 - 500P$, drawn as,
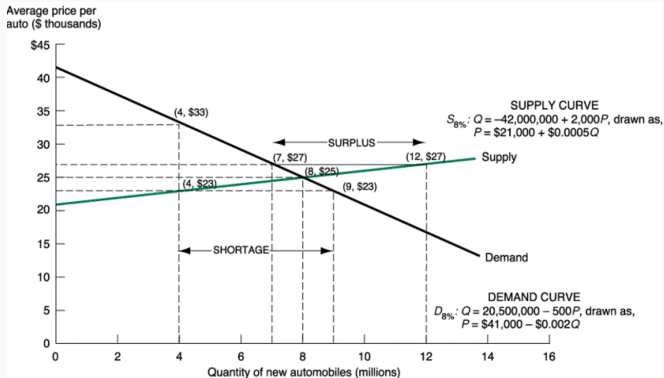$P = \$46,000 - \$0.002Q$

Demand Curve

A movement *along* the demand curve is a change in quantity demanded for a change in price, and a movement of the entire curve is a shift in various other non-price variables. For example, a change in the interest rate for a car loan may shift the entire curve.

$D_{6\%}: Q = 25,000,000 - 500P$, drawn as, $P = \$50,000 - \$0.002Q$
$D_{8\%}: Q = 23,000,000 - 500P$, drawn as, $P = \$46,000 - \$0.002Q$
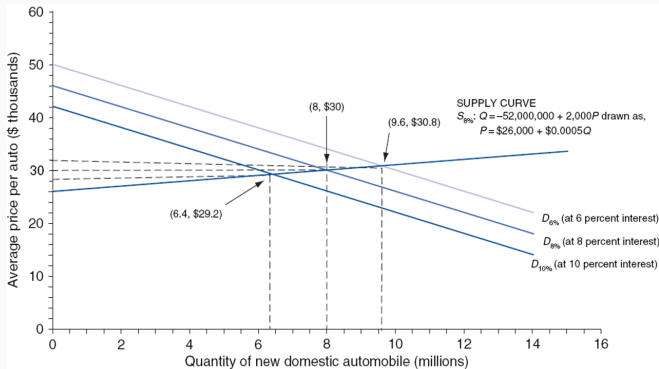$D_{10\%}: Q = 21,000,000 - 500P$, drawn as, $P = \$42,000 - \$0.002Q$

Recall that the intersection of supply and demand is the market equilibrium, and at other prices we observe shortages and surpluses.
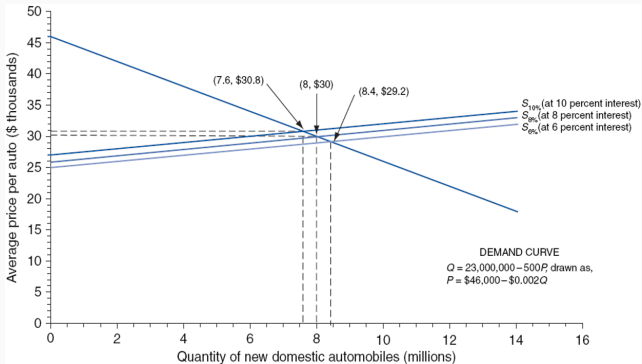
Comparative Statics

Comparative statics analysis is the study of the change in equilibrium conditions given a change in supply or demand. To see how changes in demand effect the equilibrium, we hold supply constant and analyze the changes. This is called **demand analysis**. Vice versa for supply.
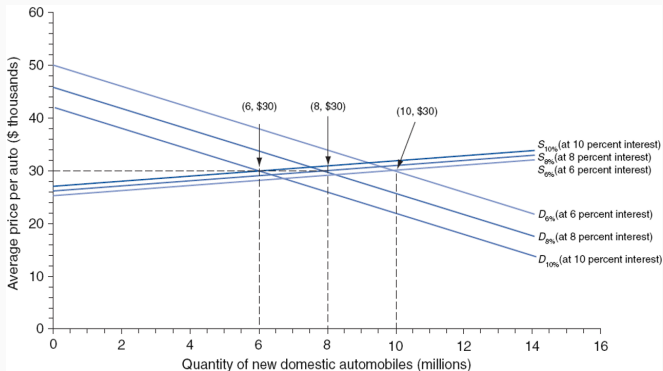
Remember how we represent a parallel shift in an estimated curve?
We use a dummy variable!

Elasticity

Elasticity is an important measure for managers. It tells us the responsiveness of quantity demanded with respect to a change in price. More generally, it is a measurement of responsiveness of the "x" variable to changes in the "y" variable. With an estimated relationship between two objects, we can find their elasticity. With elasticities, we can answer many questions:

- It is 5:01pm in New York City. Will Uber revenues rise or fall if they increase the base fare?
- What can we expect the price of corn to be if exports decrease and the domestic market is flooded?
- United Airlines is thinking about increasing ticket prices for weekend trips to warm locations in the winter. By how much can United expect revenues to rise or fall?

Elasticity

Formally, elasticity is:

$$\epsilon_{y,x} = \frac{\%\Delta y}{\%\Delta x} = \frac{dy/y}{dx/x} = \frac{dy}{dx} \cdot \frac{x}{y}$$

In previous classes, you may have calculated $\frac{dy}{dx}$ directly (rise over run). This is fine for linear functions, and equivalent to the above approach taking derivatives. However, if the function is nonlinear, the old approach becomes an *approximation*, and the derivative approach remains consistent. When profits are on the line, we like consistent estimates.

Old approach:

$$\frac{(y_{new} - y_{old})/y_{old}}{(x_{new} - x_{old})/x_{old}} = \frac{(y_{new} - y_{old})}{(x_{new} - x_{old})} \cdot \frac{x_{old}}{y_{old}}$$

New approach:

$$\frac{dy/y}{dx/x} = \frac{dy}{dx} \cdot \frac{x}{y}$$

Types of elasticities:

- Own-price
- Cross-price
- Income
- Recreational behavior to sunlight
- Angling intensity to water clarity
- Many many more

Own-price elasticity

Recall the following terminology:

- $|\epsilon_{q,p}| > 1 \Rightarrow$ demand is **elastic**: the percent change of q $>$ percent change of p
- $|\epsilon_{q,p}| < 1 \Rightarrow$ demand is **inelastic**: the percent change of q $<$ percent change of p
- $|\epsilon_{q,p}| = 1 \Rightarrow$ demand is **unitary elastic**: the percent change of q $=$ percent change of p
- $|\epsilon_{q,p}| = \infty \Rightarrow$ demand is **perfectly elastic**: at some price, you will take *any* level of q
- $|\epsilon_{q,p}| = 0 \Rightarrow$ demand is **perfectly inelastic**: at some q, you will take *any* price level

Example

Suppose you are a manager at Movie Tavern. Suppose you estimate monthly demand for tickets (q_i) as a function of the price of a ticket (p_i in dollars), the monthly subscription cost of Netflix (pN_i in dollars), and income (y_i in thousands of dollars):
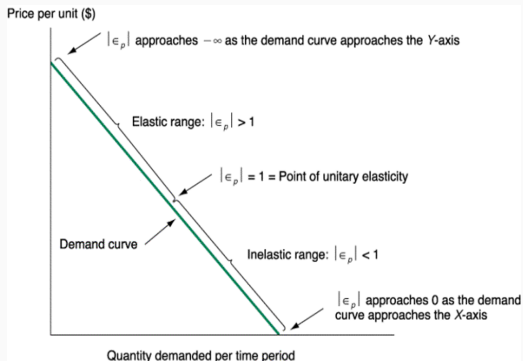
$$q_i = 7000 - 5000p_i + 6000pN_i + 150y_i$$

1. Calculate $\epsilon_{q,p}$, or own-price elasticity in general form
2. Assume $p_i = 8$, $pN_i = 10$, and $y_i = 60$. What is the exact own-price elasticity?
3. Is demand elastic or inelastic?

Elasticity of linear demand

Is elasticity of a linear demand curve constant? No. Remember: $\epsilon_{y,x} = \frac{dy}{dx} \cdot \frac{x}{y}$. Elasticity is a *function* of x and y, so location matters and elasticity is not constant.

Price per unit ($)

$|\epsilon_p|$ approaches $-\infty$ as the demand curve approaches the *Y*-axis

Elastic range: $|\epsilon_p| > 1$

$|\epsilon_p| = 1$ = Point of unitary elasticity

Demand curve

Inelastic range: $|\epsilon_p| < 1$

$|\epsilon_p|$ approaches 0 as the demand curve approaches the *X*-axis

Quantity demanded per time period

Revenues and elasticity

Remember that if given demand, we can calculate inverse demand (price as a function of quantity). Then, notice that total revenues are: $TR = p \cdot q$, but if we use inverse demand, we see that since price is a function of quantity, $TR = p(q) \cdot q$. Then, we can calculate marginal revenue as the derivative of total revenue:

$$MR = \frac{\partial TR}{\partial q} = \frac{\partial(p(q)q)}{\partial q} = p'(q)q + p = p(1 + \frac{\partial p}{\partial q} \cdot \frac{q}{p}) = p(1 + \frac{1}{\epsilon_{q,p}})$$

So we have:

$$MR = p\left(1 + \frac{1}{\epsilon_{q,p}}\right)$$

Remember that the law of demand implies $\epsilon_{q,p} < 0$. Then if demand is elastic ($|\epsilon_{q,p}| > 1$), MR will be positive. If demand is inelastic ($|\epsilon_{q,p}| < 1$), MR will be negative.

Why?

Revenues and elasticity

Since an increase in price results in a decrease in quantity demanded (thanks again, law of demand!), then when MR is positive, an increase in price will decrease revenues, and when MR is negative, an increase in price will increase revenues. When MR is negative, the increase in price and resulting reduction in demand results in *less negative loss*, which is a good thing.

From a manager's perspective, all of this background work proves the following statement: when demand is elastic, reductions in price will increase revenue, and when demand is inelastic, reductions in price will decrease revenue.

Optimal pricing

We can go further. If we know that: $MR = p\left(1 + \frac{1}{\epsilon_{q,p}}\right)$, and
(from AGEC 105) the optimal price and quantity for a monopoly is
found by setting marginal revenues equal to marginal costs, then:

$$p^* = \frac{MC}{\left(1 + \frac{1}{\epsilon_{q,p}}\right)}$$

Example

Suppose the marginal costs to produce a fly-fishing reel are constant at $25. Suppose demand elasticity is $\epsilon_{q,p} = -2$. What is the optimal price of a fly-fishing reel?

Cross-price elasticity

Remember our formula for elasticity in general:

$$\epsilon_{y,x} = \frac{dy}{dx} \cdot \frac{x}{y}$$

Then cross-price elasticity (the responsiveness of demand of one good to the price of another) is:

$$\epsilon_{q_a,p_b} = \frac{dq_a}{dp_b} \cdot \frac{p_b}{q_a}$$

Cross-price elasticity

If the quantity demanded of good A increases as a result of a price increase in good B, then the two goods are **substitutes**, and $\epsilon_{q_a, p_b} > 0$.

If the quantity demanded of good A decreases as a result of a price increase in good B, then the two goods are **complements**, and $\epsilon_{q_a, p_b} < 0$.

Cross-price elasticity

Substitutes: red bell peppers and green bell peppers, onions and shallots, raspberries and blackberries

Complements: peanut butter and jelly, yogurt and granola, Aggie polo and light blue jeans (apparently)

Compliment: "You are great and I'm really proud of the work you've done so far"

Income elasticity

Remember our formula for elasticity in general:

$$\epsilon_{y,x} = \frac{dy}{dx} \cdot \frac{x}{y}$$

Then income elasticity (the responsiveness of demand of one good to the income of an individual) is:

$$\epsilon_{q,inc} = \frac{dq}{dinc} \cdot \frac{inc}{q}$$

Income elasticity

- If $0 < \epsilon_{q,inc} < 1$, the good is a **necessary good**
- If $\epsilon_{q,inc} > 1$, the good is a **luxury good**
- If $\epsilon_{q,inc} < 0$, the good is an **inferior good**

Income elasticity

- Necessary goods: insulin, water, etc
- Luxury goods: phone cases, subscription services, etc
- Inferior goods: bologna

Example

Assume the own-price elasticity of Rudy's BBQ is $\epsilon_{q_r,p_r} = -1.5$, the cross-price elasticity of Rudy's BBQ to the price of Fargo's is $\epsilon_{q_r,p_f} = 1.2$, and the income elasticity of Rudy's is $\epsilon_{q_r,inc} = 0.01$.

1. Interpret each elasticity
2. Is demand for Rudy's elastic or inelastic?
3. If the manager of Rudy's is thinking of changing the price of BBQ, should she increase or decrease the price?
4. Is Fargo's a substitute or complement for Rudy's?
5. What kind of good is Rudy's BBQ? Do you believe that?

Empirical estimation

In the real world, demand curves are not handed to us. In the next part of this class, we will look at how to *estimate* demand. Once we estimate demand, we can calculate various elasticities. Let's talk about how to calculate elasticity from the following four model types:

- Linear-linear models
- Linear-log models
- Log-linear models
- Log-log models

Always remember that: $\epsilon_{y,x} = \frac{dy}{dx} \cdot \frac{x}{y}$

Linear-linear models

$$q_1 = \alpha + \beta_1 p_1 + \beta_2 p_2 + \phi inc + \varepsilon$$

- Own-price: $\epsilon_{q_1, p_1} = \frac{dq_1}{dp_1} \cdot \frac{p_1}{q_1} = \beta_1 \cdot \frac{p_1}{q_1}$
- Cross-price: $\epsilon_{q_1, p_2} = \frac{dq_1}{dp_2} \cdot \frac{p_2}{q_1} = \beta_2 \cdot \frac{p_2}{q_1}$
- Income: $\epsilon_{q_1, inc} = \frac{dq_1}{dinc} \cdot \frac{inc}{q_1} = \phi \cdot \frac{inc}{q_1}$

Linear-log models

$$q_1 = \alpha + \beta_1 ln(p_1) + \beta_2 ln(p_2) + \phi ln(inc) + \varepsilon$$

- Own-price: $\epsilon_{q_1, p_1} = \frac{dq_1}{dp_1} \cdot \frac{p_1}{q_1} = \frac{\beta_1}{q_1}$
- Cross-price: $\epsilon_{q_1, p_2} = \frac{dq_1}{dp_2} \cdot \frac{p_2}{q_1} = \frac{\beta_2}{q_1}$
- Income: $\epsilon_{q_1, inc} = \frac{dq_1}{dinc} \cdot \frac{inc}{q_1} = \frac{\phi}{q_1}$

$$ln(q_1) = \alpha + \beta_1 p_1 + \beta_2 p_2 + \phi\, inc + \varepsilon$$

- Own-price: $\epsilon_{q_1, p_1} = \frac{dq_1}{dp_1} \cdot \frac{p_1}{q_1} = \beta_1 \cdot p_1$
- Cross-price: $\epsilon_{q_1, p_2} = \frac{dq_1}{dp_2} \cdot \frac{p_2}{q_1} = \beta_2 \cdot p_2$
- Income: $\epsilon_{q_1, inc} = \frac{dq_1}{dinc} \cdot \frac{inc}{q_1} = \phi \cdot inc$

Log-log models

$$ln(q_1) = \alpha + \beta_1 ln(p_1) + \beta_2 ln(p_2) + \phi ln(inc) + \varepsilon$$

- Own-price: $\epsilon_{q_1,p_1} = \frac{dq_1}{dp_1} \cdot \frac{p_1}{q_1} = \beta_1$
- Cross-price: $\epsilon_{q_1,p_2} = \frac{dq_1}{dp_2} \cdot \frac{p_2}{q_1} = \beta_2$
- Income: $\epsilon_{q_1,inc} = \frac{dq_1}{dinc} \cdot \frac{inc}{q_1} = \phi$

Back to reality

The model we are about to estimate will most likely suffer from bias. The tools we need to get around that bias are pretty advanced, but we can still learn a lot from the results from the more advanced models. Here is some results from Hausman et al (1994) on the light beer segment:

Light Segment Own and Cross Elasticities.

	Genesee Light	Coors Light	Old Milwaukee Light	Lite	Molson Light
Genesee Light	−3.763	0.464	0.397	0.254	0.201
	(0.072)	(0.060)	(0.039)	(0.043)	(0.037)
Coors Light	0.569	−4.598	0.407	0.452	0.482
	(0.085)	(0.115)	(0.058)	(0.075)	(0.061)
Old Milwaukee Light . .	1.233	0.956	−6.097	0.841	0.565
	(0.121)	(0.132)	(0.140)	(0.112)	(0.087)
Lite	0.509	0.737	0.587	−5.039	0.577
	(0.095)	(0.122)	(0.079)	(0.141)	(0.083)
Molson Light	0.683	1.213	0.611	0.893	−5.841
	(0.124)	(0.149)	(0.093)	(0.125)	(0.148)

Example

Let's estimate a demand system for apple juice...